

Supplemental Geotechnical Report – Retaining Wall

for

Massachusetts Department of Transportation – Highway Division

Project File No. 608929

Complete Bridge Replacement Project

for

Bridge No. W-38-003 (C99)

Butters Row over MBTA/Pan Am Railroad

Wilmington, Massachusetts



Kin C Lam

Revision Date: 5/22/2023

Prepared for:

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1.0 EXECUTIVE SUMMARY

Based on the 2021 and 2022 boring exploration results, the proposed highway retaining wall can be supported by three rows of micropiles for the taller walls (Retaining Wall Types 1, 1A and 1B), and two rows for the shorter wall heights (Retaining Wall Types 2 and 3). The bottom of pile cap elevation varies. Each retaining wall micropile is socketed 6.5 feet into bedrock comprising of 5.5 feet bonded length and 1 foot plunge length.

The nominal and the factored micropile resistance values for bridge and retaining wall foundations are included in Section 6.0, 'Summary' of this report.

2.0 INTRODUCTION

2.1 Scope of Report

This report is supplemental to the previously prepared report for the same Butters Row Bridge # W-38-003 project. This report is prepared for the highway retaining walls along Butters Row. Its purpose is to evaluate the substructure foundation types for the proposed walls based on the 2021 & 2022 boring exploration results. The design values are prepared in AASHTO LRFD format to be compatible with the current bridge design approach.

2.2 Proposed Highway Retaining Wall

The design concept of the proposed highway retaining walls can be found on the Proposed Bridge Plan Submittal prepared by Green International Affiliates, Inc.

The new retaining walls are located from Station 52+25.07 RT. To 53+80.18 RT. for Southwest retaining wall, Station 54+90.18 RT. to 55+72.54 RT. for Southeast retaining wall, Station 51+95.02 LT. to 53+86.54 LT. for Northwest retaining wall, and Station 54+97.66 LT. to 56+34.90 LT. for Northeast retaining wall along Butters Row.

The proposed concrete cantilevered southwest retaining wall is from Station 52+25.07 RT. To 53+80.18 RT., varying from 7.5' to 19' in height, and the bottoms of footing elevation vary from Elev. 87.0 to 90.0. The proposed concrete cantilevered wall Type 2 is from Station 53+56.18 to 53+80.18. The proposed concrete cantilevered walls vary from 17.66' to 19.0' in height, and the bottom of footings elevation is Elev. 87.0. The proposed concrete cantilevered wall Type 3 is from Station 52+25.07 to 53+56.18. The proposed concrete cantilevered walls vary from 7.5' to 14.66' in height, and the bottoms of footings elevation vary from Elev. 87.5 to 90.0.

The proposed concrete cantilevered southeast retaining wall is from Station 54+90.18 to 55+72.54, varying from 20.97' to 12.6' in height, and the bottoms of footing elevation vary from Elev. 86.5 to 90.5. The proposed concrete cantilevered wall Type 1A is from Station 54+90.18 to 55+10.82. The proposed concrete cantilevered walls vary from 20.3' to 20.97' in height, and the bottom of footings elevation is Elev. 86.5. The proposed concrete cantilevered wall Type 2 is from Station 55+10.82 to 55+31.46. The proposed concrete cantilevered walls vary from 15.31' to 16.3' in height, and the bottom of footings elevation is Elev. 90.5. The proposed concrete cantilevered wall Type 3 is from Station 55+31.46 to 55+72.54. The proposed concrete

cantilevered walls vary from 15.31' to 12.6' in height, and the bottom of footings elevation is Elev. 90.5.

The proposed concrete cantilevered northwest retaining wall is from Station 51+95.02 LT. to 53+86.54 LT., varying from 24.32' to 11.62' in height, and the bottoms of footing elevation vary from Elev. 78.5 to 82.0. The proposed concrete cantilevered wall Types 1 and 1B is from Station 53+86.54 to 52+90.54. The proposed concrete cantilevered walls vary from 19' to 24.32' in height, and the bottoms of footings vary from Elev. 78.5 to 82.0. The proposed concrete cantilevered wall Type 2 is from Station 52+66.45 to 52+90.54. The proposed concrete cantilevered walls vary from 15.45' to 17.18' in height, and the bottom of footings elevation is Elev. 82.0. The proposed concrete cantilevered wall Type 3 is from Station 51+95.02 to 52+66.45. The proposed concrete cantilevered walls vary from 11.62' to 15.45' in height, and the bottom of footings elevation is Elev. 82.0

The proposed concrete cantilevered northeast retaining wall is from Station 54+97.68 LT. to 56+34.90, varying from 15.42' to 23.77' in height, and the bottom of footing elevation is Elev. 83.5. The proposed concrete cantilevered wall Type 1 is from Station 54+97.68 to 55+68.80. The proposed concrete cantilevered walls vary from 19.86' to 23.77' in height, and the bottom of footings elevation is Elev. 83.5. The proposed concrete cantilevered wall Type 2 is from Station 55+68.80 to 56+13.86. The proposed concrete cantilever walls vary from 16.74' to 19.86' in height, and the bottom of footings elevation is Elev. 83.5. The proposed concrete cantilevered wall Type 3 is from Station 56+13.86 to 56+34.90. The proposed concrete cantilevered walls vary from 15.42' to 16.74' in height, and the bottom of footings elevation is Elev. 83.5.

3.0 SUBSURFACE CONDITIONS

3.1 2022 Subsurface Exploration Program

The 2022 subsurface exploration program consisting of seven (7) test borings for the proposed retaining wall is shown on Proposed Bridge Plan Submittal prepared by Green International Affiliates, Inc. and on the attached Figures 2 & 3.

Borings CWB-6, CWB-6A and WB-7 were conducted for the Northwest Highway Retaining Wall. Borings WB-8, CWB-9 and WB-10 were conducted for the Southwest Highway Retaining Wall. Borings CWB-14 and WB-15 were conducted for the Southeast Highway Retaining Wall

Borings BB-11, CWB-12, & CWB-13 for the proposed northeast retaining wall were not drilled due to access reason. These borings are recommended to be drilled by the contractor during construction.

The 2022 explorations were performed between November 7, 2022, and November 15, 2022 by New England Boring Contractors of Derry, New Hampshire. The monitoring of the boring explorations was performed by Lamson Engineering Corporation. Materials recorded on the boring logs were visually inspected on site by the engineer from Lamson Engineering, who is also involved in the preparation of this report.

The soil samples were taken using a 2" outside diameter split spoon sampler driven into the soil by a 140-pound hammer falling 30". Blows per 6" were recorded. The classification and the description of the sample materials at the site were included on the boring logs and are also included on the soil profiles in this report.

Based on the 2021 & 2022 boring results, the predominant materials at the site are sand and gravel, with minor organic materials and occasional boulders and cobbles. Loose to very loose, fine sand materials were encountered from Elev. 78.0 to Elev. 94.5 at Borings CWB-6, WB-7, WB-8, CWB-9, and CWB-14.

3.2 Cobbles / Boulders Information

Pockets of cobbles / boulders materials were encountered during the 2022 subsurface exploration.

Table 3.2: Cobbles / Boulders Information

Boring No.	Ground Elevation (Feet)	Top of Cobble / Boulder Depth/ (Elev.)	Bot. of Cobble / Boulder Depth/ (Elev.)	Layer Thickness (Feet)	Remark
WB-7	88.0	0.5' (87.5)	5' (83)	4.5	Northwest Retaining Wall
WB-8	99.5	19.0' (80.5)	24.5' (75.0)	5.5	Southwest Retaining Wall
CWB-14	97.7	13' (84.7)	19' (78.7)	6.0	Southeast Retaining Wall

3.3 Bedrock Information

Bedrock was encountered during the 2022 boring exploration at an average Elev. 68.2.

Table 3.3: Bedrock Information

Boring No.	Ground Elevation (Feet)	Depth from Ground Surface	Top of Bedrock Elev.	RQD	Bedrock Type
CWB-6A	Elev. 88.0	22'-3"	Elev. 65.75	-	Diorite
WB-7	Elev. 88.0	18'-0"	Elev. 70.0	C1: 92% C2: 100%	Diorite
WB-8	Elev. 99.5	34'-0"	Elev. 65.0	C1: 92% C2: 100%	Diorite
WB-10	Elev. 92.4	22'-6"	Elev. 69.9	C1: 100% C2: 100%	Diorite
WB-15	Elev. 95.5	25'-0"	Elev. 70.5	C1: 88% C2: 54%	Diorite
Average			Elev. 68.2		

Note:

1. RQD = Rock Quality Designation, C1= Core Run No. 1

3.4 2022 Groundwater Information

Based on the boring logs, groundwater information can be obtained. However, the obtained groundwater information from the washed boring operation is presented for preliminary reference only.

Table 3.4: 2022 Groundwater Information Measured after Washed Boring Operation

Boring No.	Ground Elev. (Feet)	Groundwater Depth (Feet)	Estimated Groundwater Elev. (Feet)	Remark
CWB-6	Elev. 88.0	5.8	Elev. 82.2	Northwest Retaining Wall
WB-7	Elev. 88.0	5.9	Elev. 82.1	Northwest Retaining Wall
WB-8	Elev. 99.5	5.3	Elev. 84.2	Southwest Retaining Wall
CWB-9	Elev. 95.8	12.8	Elev. 83.0	Southwest Retaining Wall
WB-10	Elev. 92.4	5.8	Elev. 83.1	Southwest Retaining Wall
CWB-14	Elev. 97.7	15.5	Elev. 82.2	Southeast Retaining Wall
WB-15	Elev. 95.5	15.4	Elev. 80.1	Southeast Retaining Wall

4.0 FOUNDATION RECOMMENDATIONS

4.1 Proposed Retaining Wall Design Parameters

The following parameters are recommended for design at the back of retaining walls supported by micropiles:

Moist Unit Weight of Soil = 125 pcf (behind wall)

Soil Friction Angle = 37°

Active Lateral Earth Pressure Coefficient = 0.25

At-Rest Lateral Soil Pressure Coefficient = 0.40

Lateral earth pressure values used for design shall be in conformance with *MassDOT* BM 3.1.6.

4.2 Highway Retaining Walls

Based on Bridge Manual Section 3.3.2 and the proposed wall is greater than 14' high, cantilevered retaining wall is recommended.

Similar to the proposed bridge foundation, proposed retaining wall can be supported by concrete walls on three rows of micropiles for the taller section of wall, and two rows for the shorter wall heights. The bottom of pile cap elevation varies. Each micropile is socketed 6.5 feet into bedrock comprising of 5.5 feet bonded length and 1 foot plunge length. This elevation should be adjusted according to the actual top of bedrock found at each micropile location during construction.

The strength and material properties, nominal and factored micropile resistance values are included in Section 6.0, 'Summary' of this report.

Settlement: Since the micropile is socketed into bedrock, settlement is negligible.

4" diameter weep holes should be used behind the proposed retaining walls at 10' maximum on center to minimize hydrostatic pressure on the back of the walls.

4.3 Load Test

Based on AASHTO 10.9.3.5.4, we recommend a 'Micropile Verification Load Test' (Item 948.60) be performed on a sacrificial pile prior to ordering of production piles. We recommend the 'Micropile Verification Load Test' (Item 948.60) be performed on one sacrificial pile for the taller retaining wall. The sacrificial pile shall be within 10 feet of the footprint of a Retaining Wall Type 1, but at least 5 feet from any production pile as selected by the Contractor and accepted by the Engineer. This sacrificial pile for retaining walls is in addition to the one for the bridge abutments. These two sacrificial piles should be located on the opposite side of the bridge, i.e. separated by the tracks. Since the sacrificial pile for the bridge structure is at the west abutment, the sacrificial pile for the retaining walls should be on the east abutment side.

We also recommend 'Micropile Proof Load Test' (Item 948.61) be performed on production piles, one minimum for each of the NE, NW, SE & SW retaining walls and one minimum for each retaining wall types. Additional tests may be suggested by contractor but agree upon by the Engineer. According to AASHTO 9th Edition, Section 10.9.3.5.4, proof load tests are 1 pile for each substructure units or 5% of the total piles. Since the total micropiles are 434, the minimum proof load tests required are twenty-two (22) for bridge abutments, wingwalls, and retaining walls/ types.

The rebar size used should be greater than the Factored Design Load (FDL) for 'Micropile Proof Load Test' and 1.5 times of Factored Design Load for 'Micropile Verification Load Test'. The contractor may need to increase the size or grade of the central reinforcement steel bar for the verification load tests.

Table 4.3: Load Test for Retaining Wall and Bridge Substructure

Location of Testing Pile	Pile Type	Micropile Verification Load Test (Item 948.60)	Micropile Proof Load Test (Item 948.61)	Remark
Bridge Sub-Structures and Highway Retaining Walls	Sacrificial Pile	2	-	<ul style="list-style-type: none"> - One sacrificial pile for the bridge structure at west abutment. - One sacrificial pile for retaining walls on the east abutment side. - Prior to ordering of production piles.
	Production Pile	-	22	<ul style="list-style-type: none"> - One minimum for each of the following substructures and wall types: west abutment, east abutment, NW wingwall, SW wingwall, NE wingwall, SE wingwall, NW retaining wall- Types 1, 1B, 2 & 3, SW retaining wall- Types 2 & 3, NE retaining wall- Types 1 & 2, SE retaining wall- Types 1A, 2 & 3. - Additional tests are suggested by Contractor and accepted by the Engineer. - Initial production piles for each of the above structures.
Total:		2	22	

4.4 Soil Parameters

Based on the information in the boring logs, the following soil parameters are recommended:

Table 4.4: Recommended Soil Parameters

Structural Component	Soil Layer	Materials	Soil Unit Weight, γ	Soil Friction Angle, ϕ_f	Boring #
Highway Retaining Wall	Soil below bottom of footing	Loose Sand	115 pcf	30°	WB & CWB Borings
		Medium Dense Sand	120 pcf	32°	
		Dense Sand	125 pcf	35°	

Other applicable parameters are also included in the attached calculations.

5.0 CONSTRUCTION CONSIDERATIONS

5.1 Water Control

Since the measured water levels encountered during the 2021 and 2022 boring operation were above the bottom of the pile caps and footing, water control is expected to be needed during the proposed foundation construction.

Water levels recorded on the boring logs were not accurate due to the washed boring operation. They do not represent the water level that will be encountered during the future construction excavation operation.

The following factors should be taken into consideration for the recorded water levels:

- Groundwater levels obtained from the boring exploration operation are generally unreliable and are provided for reference only.
- Groundwater levels fluctuate over time due to seasonal changes.

5.2 Utilities

There is an underground 30" diameter sewer main near the existing bridge foundation. There are also overhead electrical, cable, and telephone lines parallel to the bridge along the south fascia. The contractor should ensure that all existing utilities affected by the construction to be relocated prior to the proposed foundation construction.

There is a 30" diameter drain line going through the northwest retaining wall. The contractor should protect this line according to the details shown on the construction plan.

5.3 Obstructions

Underground/overhead utilities, boulders, and unknown previous construction materials are potential obstruction materials that may be encountered at the site during construction. Contractor should prepare for these potential obstruction materials during the proposed foundation excavation.

5.4 Subgrade Preparation

Excavation during the bridge foundation construction should be in accordance with MassDOT Standard Specifications Section 140, 'Excavation for Structures'. Backfilling during the wall foundation construction should be in accordance with MassDOT Standard Specifications Section 150, 'Embankment'.

6.0 SUMMARY

6.1 Summary of Proposed Micropile Resistance – Highway Retaining Walls

Steel Casing: 10.75" O.D. x 0.595", API 52 ($F_y = 52$ ksi), Wall Thickness = 0.595 in, Area = 18.98 in²

Consider 1/16" Potential Corrosion, Reduced Casing Thickness = 0.5325 in, Reduced Area = 16.9 in²

Steel Reinforcing Bar: #14, Threaded, Grade 60

Cement Grout: Neat Mix of Portland Cement (Type I or II), M85 (ASTM C150), $f'_c = 5,000$ psi

Rock Socket Diameter = 9.56 in

Estimated Bonded Length into Bedrock (Grout into rock)	5.5 ft
Plunge Length (Casing into intact bedrock)	1 ft
Nominal Geotechnical Pile Resistance per Pile	297 kips
Side Resistance Factor, ϕ_{stat}	0.55
Tip Resistance Factor on Rock, ϕ_{stat}	0.50
Factored Geotechnical Pile Resistance per Pile	164 kips
Nominal Uplift Resistance per Pile	149 kips
Resistance Factor, ϕ_{up}	0.55
Factored Uplift Resistance per Pile	82 kips

Nominal Structural Pile Resistance per Pile = 1,097 kips (Portion of Cased Length)
 Nominal Structural Pile Resistance per Pile = 366 kips (Portion of Uncased Length)
 Compression Resistance Factor, ϕ_c = 0.75

Factored Structural Pile Resistance per Pile = 823 kips (Portion of Cased Length)
 Factored Structural Pile Resistance per Pile = 274 kips (Portion of Uncased Length)

Nominal Tension Resistance = 995 kips (Portion of Cased Length)
 Nominal Tension Resistance = 135 kips (Portion of Uncased Length)
 Tension Resistance Factor, ϕ_T = 0.80

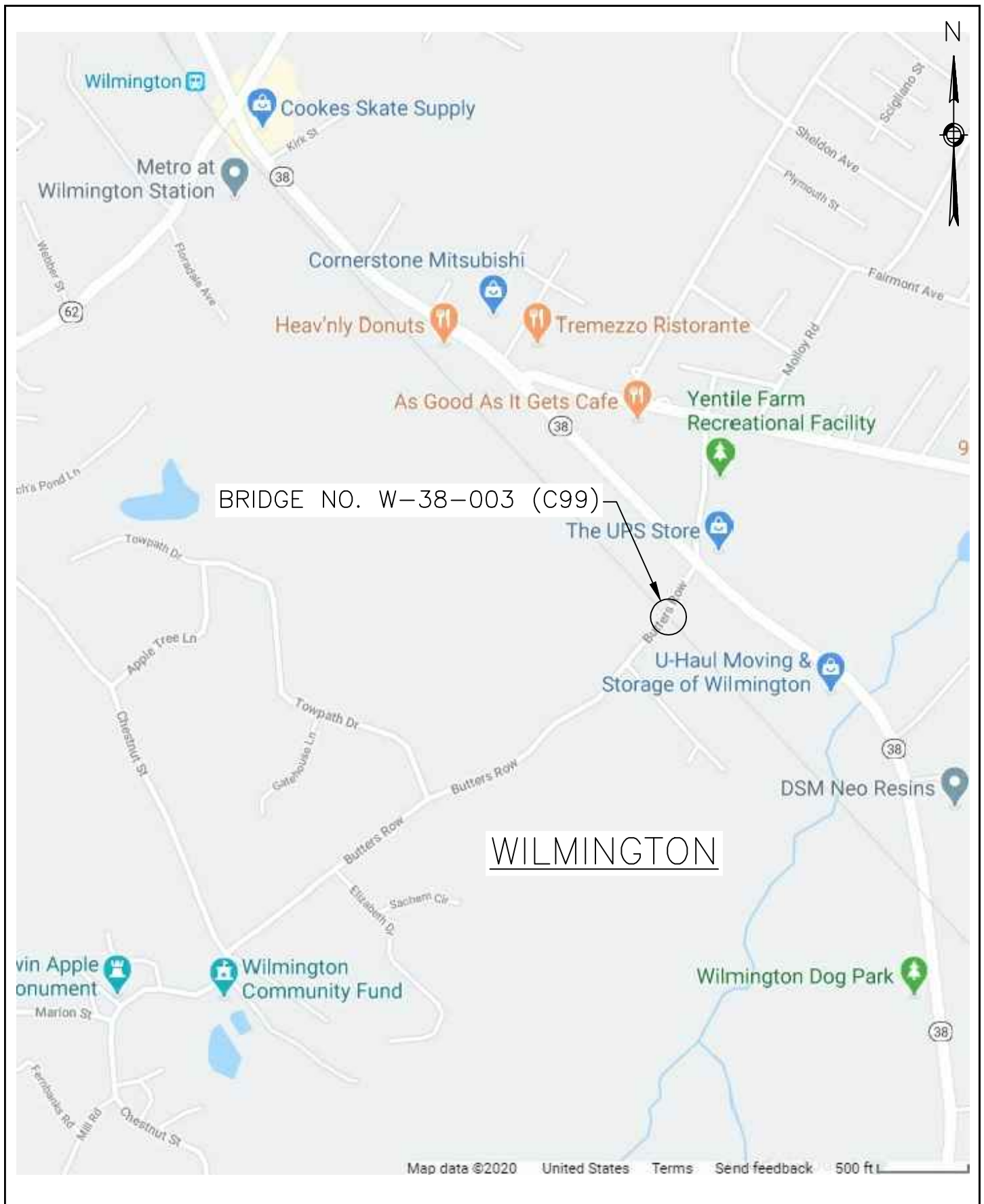
Factored Tension Resistance = 796 kips (Portion of Cased Length)
 Factored Tension Resistance = 108 kips (Portion of Uncased Length)

6.2 Summary of Micropile Shear Resistance at 1" Lateral Displacement *

Type	Highway Retaining Wall Types 1, 1A and 1B	Highway Retaining Wall Types 2 and 3
10.75" x 0.595" Micropile per Pile	28 kips	31 kips

* At the top of the pile (bottom of footing).

FIGURES



GREEN INTERNATIONAL AFFILIATES, INC.
BRIDGE NO. W-38-003 (C99)
BUTTERS ROW OVER MBTA/PAN AM RAILROAD
WILMINGTON, MASSACHUSETTS

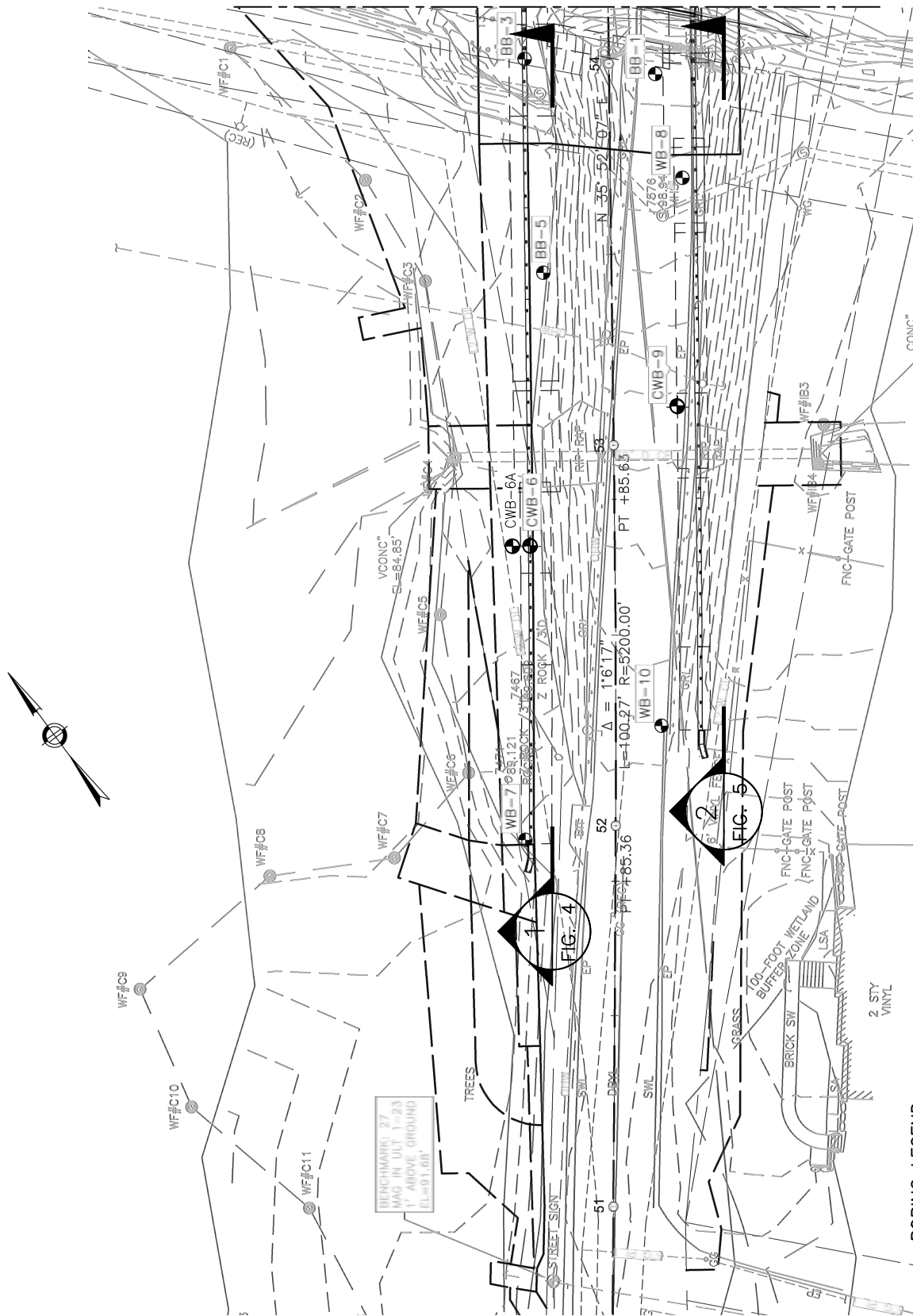


PROJECT LOCATION PLAN
AS NOTED

PREPARED BY
LAMSON ENGINEERING CORP.
NEWTON, MASS.

Fig. 1

CONTINUED ON FIG. 3



BORING LEGEND

- BB-# 2021 BRIDGE BORING
- WB-# 2022 WALL BORING
- CWB-# 2022 COMPLEMENTARY WALL BORING
- CWB-# BORING TO BE TAKEN BY CONTRACTOR DURING CONSTRUCTION



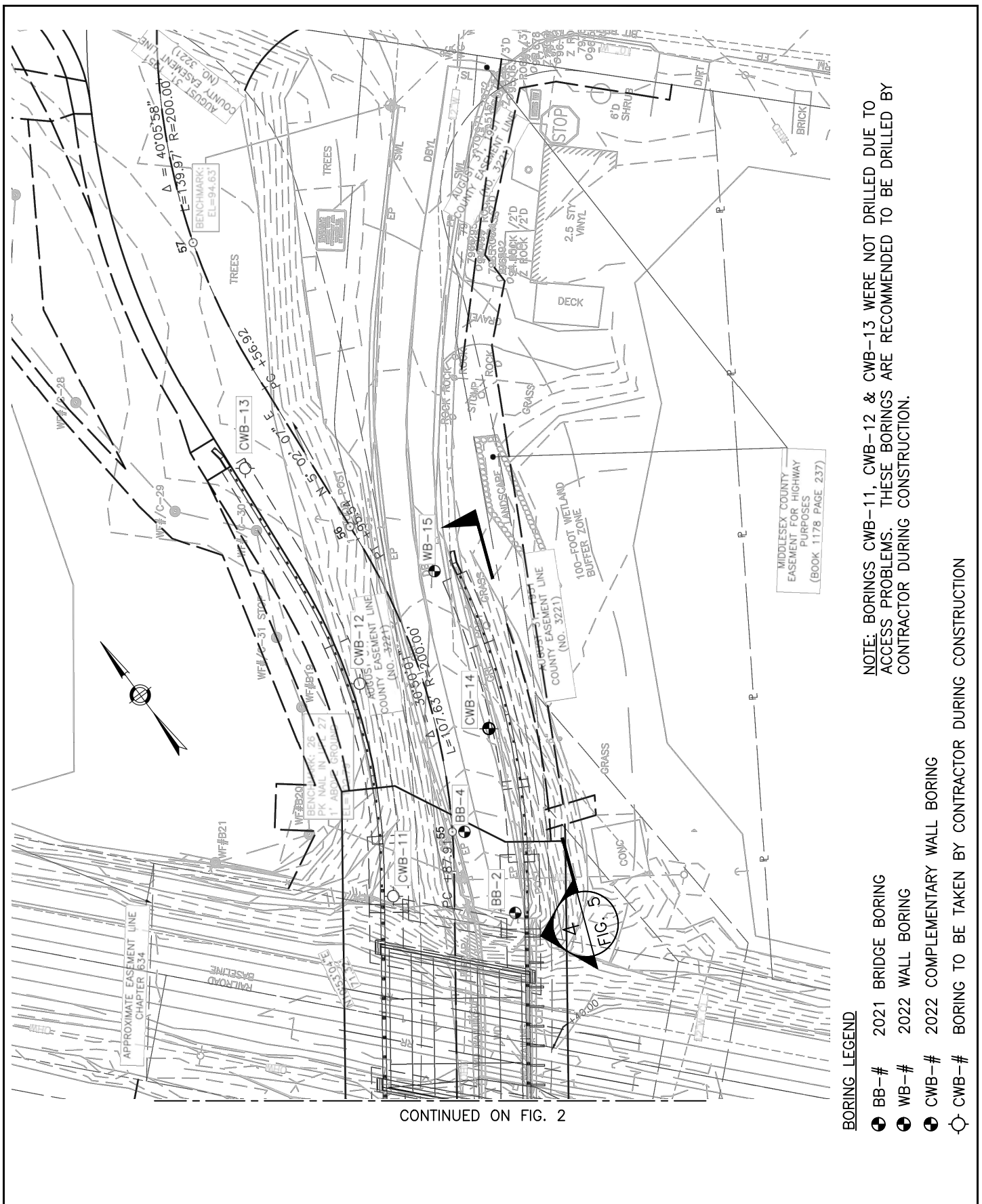
GREEN INTERNATIONAL AFFILIATES, INC.
BRIDGE NO. W-38-003 (C99)
BUTTERS ROW OVER MBTA/PAN AM RAILROAD
WILMINGTON, MASSACHUSETTS

AS-DRILLED BORING LOCATION PLAN (1/2)

NOT TO SCAL

PREPARED BY
LAMSON ENGINEERING CORP.
NEWTON, MASS.

Fig. 2



BORING LEGEND

- BB-# 2021 BRIDGE BORING
- WB-# 2022 WALL BORING
- CWB-# 2022 COMPLEMENTARY WALL BORING
- CWB-# BORING TO BE TAKEN BY CONTRACTOR DURING CONSTRUCTION

NOTE: BORINGS CWB-11, CWB-12 & CWB-13 WERE NOT DRILLED DUE TO ACCESS PROBLEMS. THESE BORINGS ARE RECOMMENDED TO BE DRILLED BY CONTRACTOR DURING CONSTRUCTION.



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BRIDGE NO. W-38-003 (C99)
BUTTERS ROW OVER MBTA/PAN AM RAILROAD
WILMINGTON, MASSACHUSETTS

AS-DRILLED BORING LOCATION PLAN (2/2)

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Fig. 3

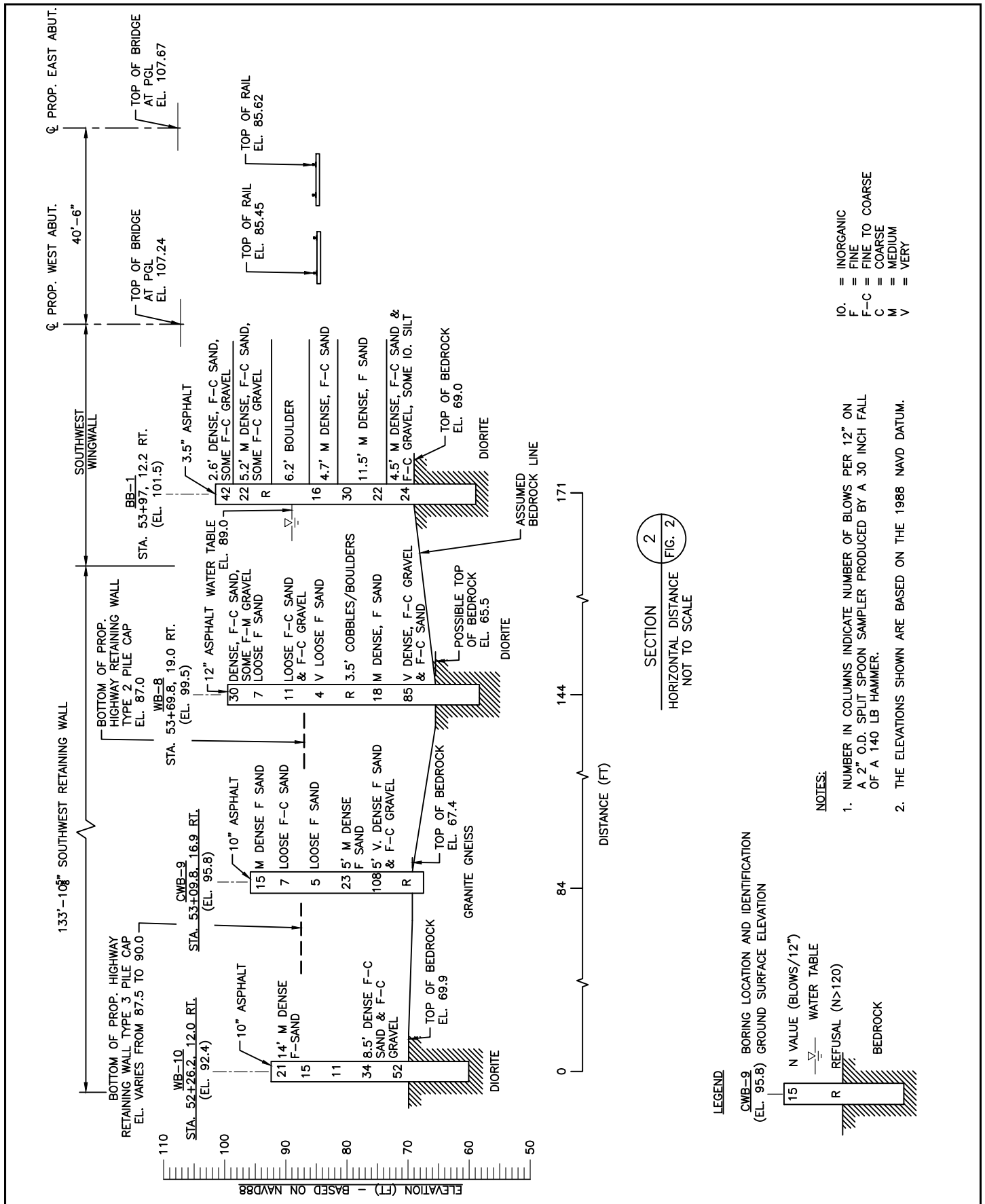


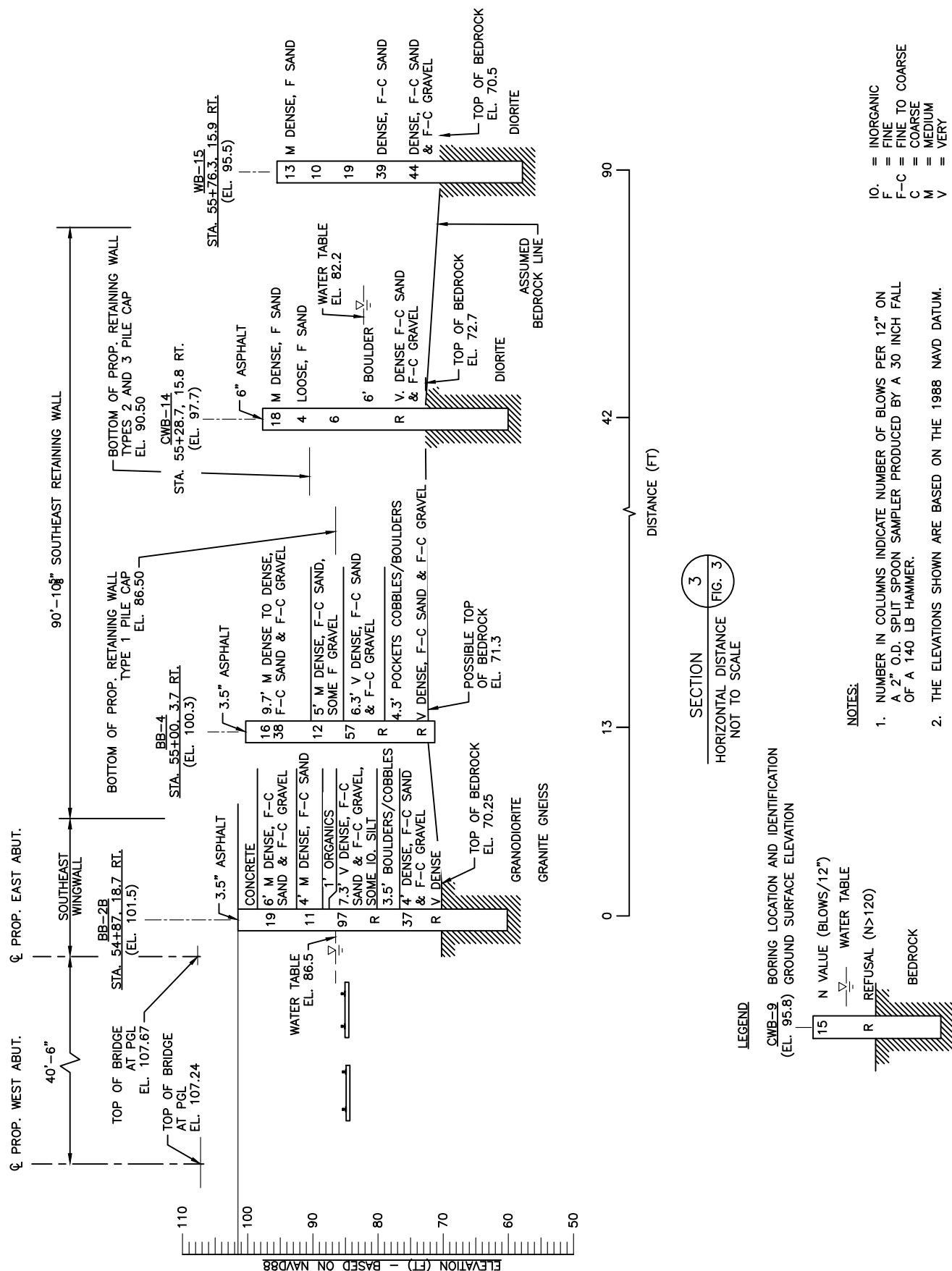
Fig. 5

SOIL PROFILE – DESCRIPTIVE VIEW (3/3)

SCALE: $3/64" = 1'-0"$

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Fig. 6



NOTES:

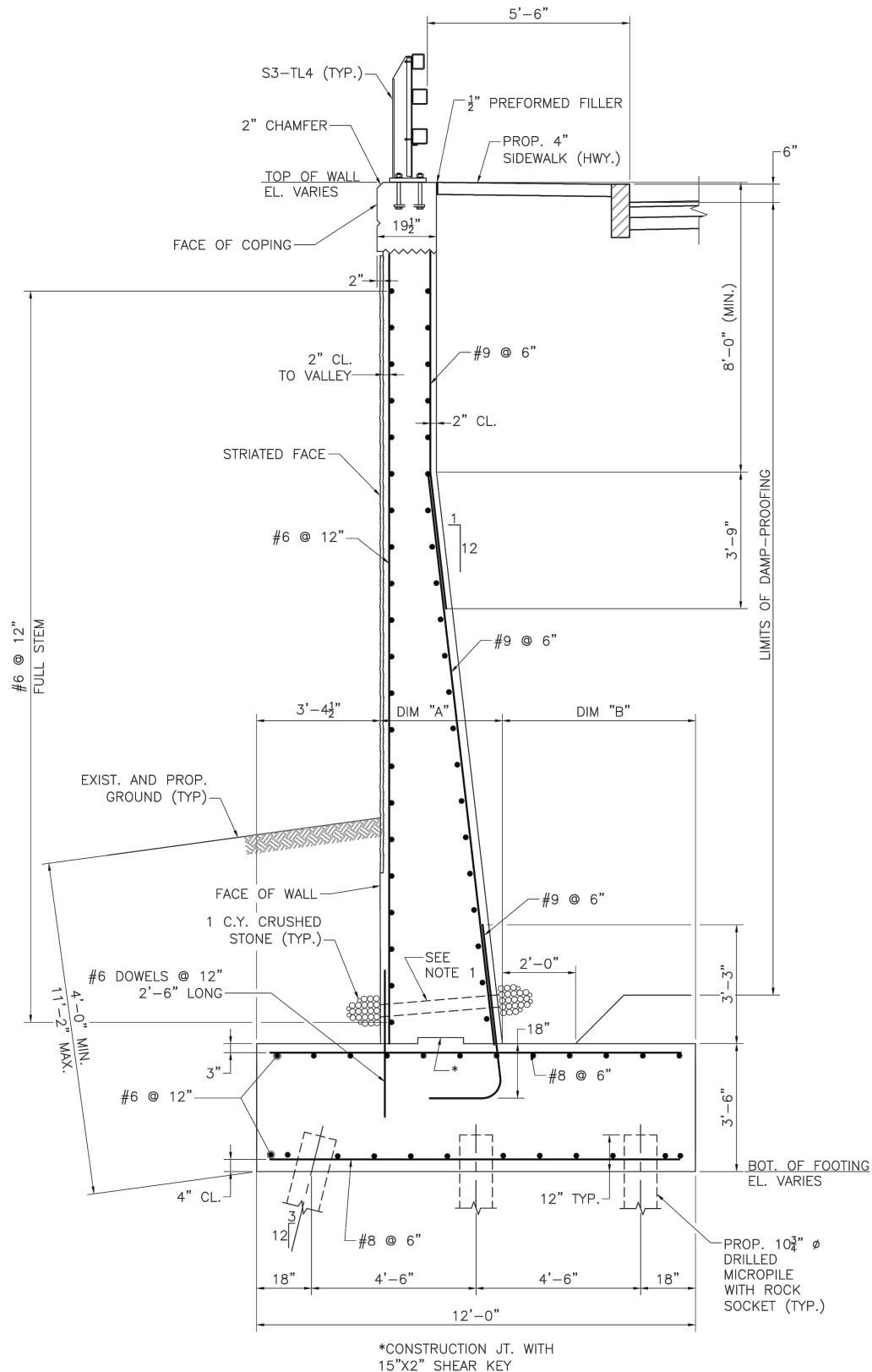
1. NUMBER IN COLUMNS INDICATE NUMBER OF BLOWS PER 12" ON A 2" O.D. SPLIT SPOON SAMPLER PRODUCED BY A 30 INCH FALL OF A 140 LB HAMMER.
2. THE ELEVATIONS SHOWN ARE BASED ON THE 1988 NAVD DATUM.
- IO. = INORGANIC
F = FINE
F-C = FINE TO COARSE
C = COARSE
M = MEDIUM
V = VERY

IO.	=	INORGANIC
F	=	FINE
F-C	=	FINE TO COARSE
C	=	COARSE
M	=	MEDIUM
V	=	VERY

massDOT

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BRIDGE NO. W-38-003 (C99)
BUTTERS ROW OVER MBTA/PAN AM RAILROAD
WILMINGTON, MASSACHUSETTS

A00882 - 21



PROPOSED RETAINING WALL TYPES 1A & 2A SECTION

SOURCE: FROM GREEN'S PLANS SUBMITTAL.

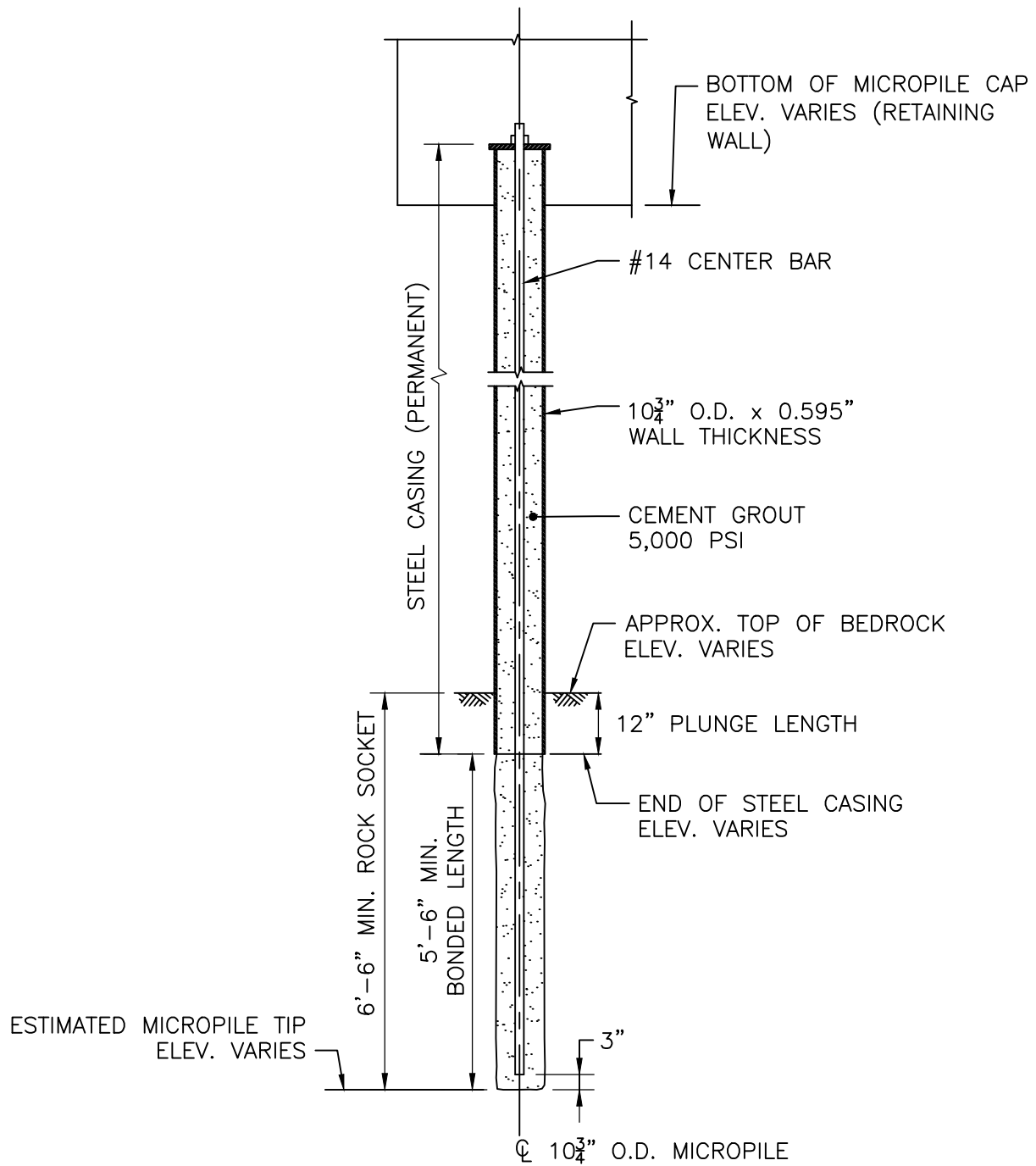


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BRIDGE NO. W-38-003 (C99)
BUTTERS ROW OVER MBTA/PAN AM RAILROAD
WILMINGTON, MASSACHUSETTS

PROPOSED RETAINING WALL TYPES 1A & 2A
SECTION
SCALE: NOT TO SCALE

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Fig. 8



GREEN INTERNATIONAL AFFILIATES, INC.
 BRIDGE NO. W-38-003 (C99)
 BUTTERS ROW OVER MBTA/PAN AM RAILROAD
 WILMINGTON, MASSACHUSETTS

PROPOSED RETAINING WALL MICROPILE

SCALE: NOT TO SCALE

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Fig. 10

APPENDIX 1

2021 & 2022 Subsurface Exploration Results

(17 sheets)

1. There are 17 sheets for Borings BB-1, BB-3, BB-4, BB-5, CWB-6, CWB-6A, CWB-14, WB-7, WB-8, CWB-9, WB-10, and WB-15.
2. Borings BB-1, BB-3, BB-4, & BB-5 were drilled in 2021,
3. Borings CWB-6, CWB-6A, CWB-9, CWB-14, WB-7, WB-8, WB-10, and WB-15 were drilled in 2022.
4. The elevations shown on the attached 2020 & 2022 logs are based on 1988 NAVD datum.

**LAMSON ENGINEERING CORPORATION**
 437 Cherry Street, #109, Newton, Massachusetts 02465
 Phone: (617) 558-0101 E-Mail: Lamsoneng@msn.com
Boring No. BB-1Page
1/2

Scale: 1" = 5'

City/Town: Wilmington				Bridge No.: W-38-003 (2NV)				Project File No.: 608929				Contract No.: -					
Location: Butters Row over MBTA/PAN AM Railroad								Date & Time Started: 1/12/21 10:30 a.m.						Total Hours:			
Groundwater Depth (Feet): 12.6' Date & Time: 1/13/21 1:00 p.m.								Date & Time Completed: 1/13/21 1:30 p.m.						9.5			
Coordinates: N 3,021,503				E 746,507				Ground Elevation (Feet): 101.5'				Inspector's Name: Weijie Dong					
Drilling Company: New England Boring Contractors								*Driller's Name: Brett Raiche				*Helper's Name: Brian Steen					
Sample Number	Depth Range (Feet)	Blow Counts per 6 Inches					Recovery (inches)	Field Description						Strata Changes			
		Coring Times Minute Per Foot															
S-1	1' - 3'	9	24	18	15	9"	Asphalt 3.5"										
							Dry, dense, brown, FINE TO COARSE SAND, some fine to coarse gravel, trace inorganic silt.										
S-2	4' - 6'	6	12	10	13	6"	Dry, medium dense, brown, FINE TO COARSE SAND, some fine to coarse gravel, trace inorganic silt.										
S-3	9' - 9'2"	120/2"				0"	No Recovery						9'2"				
							Boulder						15'4"				
S-4	15'6" - 17'6"	4	3	13	13	15"	Wet, medium dense, brown, FINE TO COARSE SAND, trace fine gravel.										
S-5	19' - 21'	11	13	17	15	13"	Wet, medium dense, brown, FINE SAND.										
S-6	24' - 26'	7	10	12	16	14"	Wet, medium dense, gray, FINE SAND, some inorganic silt.						24'				
S-7	30' - 32'	20	15	9	12	7"	Wet, medium dense, gray, FINE TO COARSE SAND AND FINE TO COARSE GRAVEL, some inorganic silt. Top of Bedrock @ 32'6"						32'6"				
							Rollerbit to 34' and begin coring.										
C-1	34' - 39'	4	4	5	5	4	60"	Fresh, hard, gray, DIORITE. Percent Recovery = 100% RQD = 60"/60" = 100%									

**Boring Log****LAMSON ENGINEERING CORPORATION**

437 Cherry Street, #109, Newton, Massachusetts 02465
 Phone: (617) 558-0101 E-Mail: Lamsoneng@msn.com

Boring No. BB-1
 Page
 2/2

Scale: 1" = 5'

Sample Number	Depth Range (Feet)	Blow Counts per 6 Inches					Recovery (inches)	Field Description	Strata Changes
		Coring Times	Minute	Per Foot					
C-2	39' - 44'	4	4	4	5	4	60"	Fresh, hard, gray, DIORITE. Percent Recovery = 100% RQD = 54"/60" = 90%	44'
								Bottom of Exploration @ 44'	

Notes:

* Mark D'Ambrosio and Cody Richards took over on 1/13/21 using Truck rig - GT8.

 Arrow-Board: -
 Signs: 2
 Cones: 6

 Protective Device Stand: - Box: -
 Well Depth: - Solid Pipe: -
 Stick Up Pipe: - Screen Pipe: -
Penetration Resistance (N) Guide:

Cohesionless Soils (Sands, Gravels)		Cohesive Soils (Silts, Clays)		Type of Drill Rig: Soil Scout	
Relative Density	Penetration Resistance	Consistency	Penetration Resistance	Hammer Weight: 140 lbs	Fall: 30"
Very Loose	0 - 4	Very Soft	0 - 2	Casing Types: HW	NW
Loose	4 - 10	Soft	2 - 4	Size: 4"	3"
Medium Dense	10 - 30	Medium Stiff	4 - 8	Depth: 9'	34'
Dense	30 - 50	Stiff	8 - 15	Sampler Type: S/S Size: 1 3/8" ID Automatic Hammer Weight: Safety Hammer Weight: 140 lbs Donut Hammer Weight: Fall: 30"	
Very Dense	Over 50	Very Stiff	15 - 30		
N=Sum of Second and Third 6" Blow Counts		Hard	Over 30		
Terms Used for Second Entry of Descriptions: and = 40-50%, some = 10-40%, trace = 10% or less				Core Barrel Type: NX Size: 2.155"	

**LAMSON ENGINEERING CORPORATION**

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Boring No. BB-3Page
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Scale: 1" = 5'

City/Town: Wilmington			Bridge No.: W-38-003 (2NV)			Project File No.: 608929			Contract No.: -						
Location: Butters Row over MBTA/PAN AM Railroad						Date & Time Started: 1/11/21 7:00 a.m.				Total Hours:					
Groundwater Depth (Feet): 4.0'						Date & Time: 1/11/21 1:00 p.m.			Date & Time Completed: 1/11/21 1:30 p.m.			6.5			
Coordinates: *N 3,021,527			*E 746,470			Ground Elevation (Feet): *87.2'			Inspector's Name: Weijie Dong						
Drilling Company: New England Boring Contractors						Driller's Name: Brett Raiche			Helper's Name: Brian Steen						
Sample Number	Depth Range (Feet)	Blow Counts per 6 Inches				Recovery (inches)	Field Description				Strata Changes				
		Coring Times Minute Per Foot													
S-1	0' - 2'	6	9	5	8	10"	Topsoil 4"								
							Dry, medium dense, black, FINE TO COARSE SAND, some organic silt, trace fine gravel.								
S-2	4' - 6'	4	4	4	8	0"	No Recovery (Loose materials, black, Sand & Organic Silt from Wash)				8'2"				
S-3	10' - 12'	4	3	4	7	4"	WOOD				9'6"				
							Wet, loose, brown, FINE TO COARSE SAND, trace fine gravel.								
S-4	14' - 16'	2	12	6	5	10"	Wet, medium dense, brown, FINE TO COARSE SAND, trace fine gravel.						20'3"		
S-5	19' - 20'3"	11	17	80/3"		8"	Wet, very dense, brown, FINE TO COARSE SAND, some fine to coarse gravel, trace inorganic silt. Top of Bedrock @ 20'3"				30'6"				
C-1	20'6" - 25'6"	5	6	6	5	6	60"	Rollerbit to 20'6" and begin coring. Fresh, hard, slightly fractured, gray, GRANITE GNEISS. Percent Recovery = 100% RQD = 50"/60" = 83%							
C-2	25'6" - 30'6"	6	5	5	6	6	60"	Fresh, hard, slightly fractured, gray, GRANITE GNEISS. Percent Recovery = 100% RQD = 53"/60" = 88%							
							Bottom of Exploration @ 30'6"								
Notes:							Arrow-Board: -		Protective Device		Stand: -		Box: -		
* Moved 12'± West due to slope. Coordinates and elevation are estimated.							Signs: -		Well Depth: -		Solid Pipe: -				
							Cones: -		Stick Up Pipe: -		Screen Pipe: -				
Penetration Resistance (N) Guide:								Type of Drill Rig: Soil Scout							
Cohesionless Soils (Sands, Gravels)					Cohesive Soils (Silts, Clays)					Hammer Weight: 140 lbs				Fall: 30"	
Relative Density		Penetration Resistance			Consistency		Penetration Resistance			Casing Types: HW				NW	
Very Loose		0 - 4			Very Soft		0 - 2			Size: 4"		3"			
Loose		4 - 10			Soft		2 - 4			Depth: 9'		20'			
Medium Dense		10 - 30			Medium Stiff		4 - 8			Sampler Type: S/S				Size: 1 3⁄8" ID	
Dense		30 - 50			Stiff		8 - 15			Automatic Hammer Weight:					
Very Dense		Over 50			Very Stiff		15 - 30			Safety Hammer Weight: 140 lbs					
N=Sum of Second and Third 6" Blow Counts					Hard		Over 30			Donut Hammer Weight:				Fall: 30"	
Terms Used for Second Entry of Descriptions: and = 40-50%, some = 10-40%, trace = 10% or less								Core Barrel Type: NX						Size: 2.155"	

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Boring No. BB-4Page
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Scale: 1" = 5'

City/Town: Wilmington		Bridge No.: W-38-003 (2NV)		Project File No.: 608929		Contract No.: -		
Location: Butters Row over MBTA/PAN AM Railroad				Date & Time Started: 1/15/21 10:30 a.m.		Total Hours:		
Groundwater Depth (Feet): 14.0' Date & Time: 1/15/21 2:00 p.m.				Date & Time Completed: 1/15/21 2:30 p.m.		4		
Coordinates: N 3,021,592		E 746,560		Ground Elevation (Feet): 100.3'		Inspector's Name: Weijie Dong		
Drilling Company: New England Boring Contractors				Driller's Name: Mark D'Ambrosio		Helper's Name: Cody Richards		
Sample Number	Depth Range (Feet)	Blow Counts per 6 Inches Coring Times Minute Per Foot				Recovery (inches)	Field Description	Strata Changes
S-1	2' - 4'	16	10	6	8	12"	Asphalt 3.5"	
							Dry, medium dense, black, FINE TO COARSE SAND AND FINE TO COARSE GRAVEL, trace inorganic silt.	
S-2	4' - 6'	40	20	18	20	12"	Dry, dense, brown, FINE TO COARSE SAND AND FINE TO COARSE GRAVEL, trace inorganic silt.	
S-3	10' - 12'	4	6	6	7	10"	Dry, medium dense, brown, FINE TO COARSE SAND, some fine gravel, trace inorganic silt.	
S-4	15' - 17'	13	24	33	35	15"	Wet, very dense, brown, FINE TO COARSE SAND AND FINE TO COARSE GRAVEL, trace inorganic silt.	
S-5	20' - 21'4"	27	20	100/4"	7"	Wet, very dense, brown, FINE TO COARSE SAND AND FINE TO COARSE GRAVEL, trace inorganic silt.	21'4"	
S-6	26' - 26'2"	120/2"			2"	Cobble 21'9"		
						Brown, Sand & Gravel from Wash.	24'6"	
						Boulder	26'	
						Wet, very dense, brown, FINE TO COARSE SAND AND FINE TO COARSE GRAVEL, trace inorganic silt. Possible Top of Bedrock @ 29'	29'	
						Rollerbit to 30'. Bottom of Exploration @ 30'	30'	
Notes:						Arrow-Board: - Signs: 4 Cones: 6	Protective Device Stand: - Box: - Well Depth: - Solid Pipe: - Stick Up Pipe: - Screen Pipe: -	
Penetration Resistance (N) Guide:						Type of Drill Rig: Truck - GT8		
Cohesionless Soils (Sands, Gravels)			Cohesive Soils (Silts, Clays)			Hammer Weight: 300 lbs Fall: 24"		
Relative Density	Penetration Resistance	Consistency	Penetration Resistance	Casing Types: HW NW				
Very Loose	0 - 4	Very Soft	0 - 2	Size: 4" 3"				
Loose	4 - 10	Soft	2 - 4	Depth: 20' 26'				
Medium Dense	10 - 30	Medium Stiff	4 - 8	Sampler Type: S/S Size: 1 3/8" ID				
Dense	30 - 50	Stiff	8 - 15	Automatic Hammer Weight:				
Very Dense	Over 50	Very Stiff	15 - 30	Safety Hammer Weight: 140 lbs				
N=Sum of Second and Third 6" Blow Counts			Hard	Over 30	Donut Hammer Weight: Fall: 30"			
Terms Used for Second Entry of Descriptions: and = 40-50%, some = 10-40%, trace = 10% or less						Core Barrel Type: - Size: -		

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Boring No. BB-5Page
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Scale: 1" = 5'

City/Town: Wilmington		Bridge No.: W-38-003 (2NV)		Project File No.: 608929		Contract No.: -	
Location: Butters Row over MBTA/PAN AM Railroad				Date & Time Started: 1/11/21 1:30 p.m.		Total Hours:	
Groundwater Depth (Feet): 5.5' Date & Time: 1/12/21 9:00 a.m.				Date & Time Completed: 1/12/21 9:30 a.m.		4.5	
Coordinates: N 3,021,479		E 746,453		Ground Elevation (Feet): 88.7'		Inspector's Name: Weijie Dong	
Drilling Company: New England Boring Contractors				Driller's Name: Brett Raiche		Helper's Name: Brian Steen	
Sample Number	Depth Range (Feet)	Blow Counts per 6 Inches		Recovery (inches)	Field Description		Strata Changes
		Coring Times Minute Per Foot					
S-1	0' - 2'	8	16	18	14	10"	Topsoil 4"
		Dry, dense, brown, FINE TO COARSE SAND, some fine gravel, trace inorganic silt.					
S-2	4' - 6'	6	8	12	14	13"	Dry, medium dense, brown, FINE SAND, trace wood, trace inorganic silt.
S-3	9' - 11'	3	3	4	4	12"	Wet, loose, brown, FINE SAND, some inorganic silt.
S-4	14' - 16'	1	2	6	42	8"	Wet, loose, gray, FINE SAND, some inorganic silt.
		Possible Top of Bedrock @ 17'					17'
		Rollerbit to 18'6".					18'6"
		Bottom of Exploration @ 18'6"					
Notes:						Arrow-Board: -	Protective Device Stand: - Box: -
						Signs: -	Well Depth: - Solid Pipe: -
						Cones: -	Stick Up Pipe: - Screen Pipe: -
Penetration Resistance (N) Guide:						Type of Drill Rig: Soil Scout	
Cohesionless Soils (Sands, Gravels)				Cohesive Soils (Silts, Clays)		Hammer Weight: 140 lbs Fall: 30"	
Relative Density		Penetration Resistance		Consistency		Casing Types: HW	
						Size: 4"	
Very Loose		0 - 4		Very Soft		Depth: 14'	
Loose		4 - 10		Soft			
Medium Dense		10 - 30		Medium Stiff		Sampler Type: S/S Size: 1 3/8" ID	
Dense		30 - 50		Stiff		Automatic Hammer Weight:	
Very Dense		Over 50		Very Stiff		Safety Hammer Weight: 140 lbs	
N=Sum of Second and Third 6" Blow Counts				Hard		Donut Hammer Weight: Fall: 30"	
Terms Used for Second Entry of Descriptions: and = 40-50%, some = 10-40%, trace = 10% or less						Core Barrel Type: - Size: -	

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Boring No. CWB-6Page
1/1

Scale: 1" = 5'

City/Town: Wilmington			Bridge No.: W-38-003 (2NV)			Project File No.: 608929			Contract No.: -		
Location: Butters Row over MBTA/PAN AM Railroad						Date & Time Started: 11/7/22 9:30 AM				Total Hours:	
Groundwater Depth (Feet): 4.9' Date & Time: 11/7/22 12:15 PM						Date & Time Completed: 11/7/22 12:15 PM				3.25	
Coordinates: *N 3,021,420			*E 746,406			Ground Elevation (Feet): 88.0'			Inspector's Name: Edward Mahoney		
Drilling Company: New England Boring Contractors					Driller's Name: Mark D' Ambrosio				Helper's Name: Cody Richards		
Sample Number	Depth Range (Feet)	Blow Counts per 6 Inches				Recovery (inches)	Field Description	Strata Changes			
		Coring Times Minute Per Foot									
S-1	0' - 2'	5	11	18	18	14"	3" Topsoil	3"			
S-2	2' - 4'	17	18	22	13	11"	Dry, medium dense, brown, FINE TO COARSE SAND AND FINE TO COARSE BROKEN GRAVEL.				
							2'6"				
S-3	5' - 7'	10	12	10	13	13"	Dry, dense, brown, FINE SAND, some fine to medium gravel, trace coarse sand, inorganic silt. (Fill Cobble/Boulder 0'-5')				
							5'				
S-4	10' - 12'	3	4	4	21	15"	Wet, medium dense, light brown, FINE SAND, trace inorganic silt.				
							13'				
S-5	15' - 17'	14	30	24	16	10"	Wet, loose, gray, FINE SAND, trace inorganic silt.				
							13'				
							20'				
							Wet, very dense, gray, FINE TO COARSE SAND, some fine to medium gravel, trace inorganic silt.				
							Casing broken off @ 20', start SWB - 6A				
							- 10' of 3" casing broken off in hole.				
							- 5' of 4" casing broken off in hole.				
							Bottom of Exploration @ 20'				

Notes:

* Moved CWB-6 3' further away from road due to setup, from N 3,021,418 E 746,408 to N 3,021,420 E 746,406

Arrow-Board: -

Signs: 2

Cones: 12

Protective Device Stand: - Box: -

Well Depth: - Solid Pipe: -

Stick Up Pipe: - Screen Pipe: -

Penetration Resistance (N) Guide:

Cohesionless Soils (Sands, Gravels)		Cohesive Soils (Silts, Clays)		Type of Drill Rig: Truck rig - GT8	
Relative Density	Penetration Resistance	Consistency	Penetration Resistance	Hammer Weight: 140 lbs	Fall: 30"
Very Loose	0 - 4	Very Soft	0 - 2	Casing Types: Drive	Spin
Loose	4 - 10	Soft	2 - 4	Size: HW(4")	NW(3")
Medium Dense	10 - 30	Medium Stiff	4 - 8	Depth: 15'	20'
Dense	30 - 50	Stiff	8 - 15	Sampler Type: S/S Size: 1 3/8" ID	
Very Dense	Over 50	Very Stiff	15 - 30	Automatic Hammer Weight: 140 lbs	
N=Sum of Second and Third 6" Blow Counts		Hard	Over 30	Safety Hammer Weight:	
Terms Used for Second Entry of Descriptions: and = 40-50%, some = 10-40%, trace = 10% or less				Donut Hammer Weight: Fall: 30"	
				Core Barrel Type: Size:	

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Boring No. CWB-6APage
1/1

Scale: 1" = 5'

City/Town: Wilmington			Bridge No.: W-38-003 (2NV)			Project File No.: 608929			Contract No.: -		
Location: Butters Row over MBTA/PAN AM Railroad						Date & Time Started: *11/7/22 1:30 PM				Total Hours:	
Groundwater Depth (Feet): 5.8' Date & Time: 11/15/22 1:00 PM						Date & Time Completed: *11/15/22 1:15 PM				7.0	
Coordinates: **N 3,021,422 **E 746,404			Ground Elevation (Feet): 88.0'			Inspector's Name: Edward Mahoney					
Drilling Company: New England Boring Contractors					Driller's Name: Mark D' Ambrosio			Helper's Name: Cody Richards			
Sample Number	Depth Range (Feet)	Blow Counts per 6 Inches Coring Times Minute Per Foot			Recovery (inches)	Field Description					Strata Changes
C-1	20'3" - 23'	1.5 1.5 4/ 9"			9"	For sample to 17', refer to SWB - 6					
						Drive 4" casing to 20'					
						Rollerbit to 20'3" Hard at 20'3"					
						20'3" - 22'3" Cobbles					
						Top of Bedrock @ 22'3"					
						Fresh, hard, slightly fractured, gray, DIORITE.					22'3"
						Bottom of Exploration @ 23'					23'0"

Notes:

* Operation time: 11/7/22 1:30 PM to 3:15 PM, 11/15/22 8:00 AM to 1:15 PM.
 ** Moved CWB-6A 3' away from CWB-6, from N 3,021,420 E 746,406 to N 3,021,422 E 746,404

Arrow-Board: -
 Signs: 2
 Cones: 12

Protective Device Stand: - Box: -
 Well Depth: - Solid Pipe: -
 Stick Up Pipe: - Screen Pipe: -

Penetration Resistance (N) Guide:

Cohesionless Soils (Sands, Gravels)		Cohesive Soils (Silts, Clays)		Type of Drill Rig: Truck rig - GT8
Relative Density	Penetration Resistance	Consistency	Penetration Resistance	Hammer Weight: 140 lbs Fall: 30"
Very Loose	0 - 4	Very Soft	0 - 2	Casing Types: Drive
Loose	4 - 10	Soft	2 - 4	Size: HW(4")
Medium Dense	10 - 30	Medium Stiff	4 - 8	Depth: 20'
Dense	30 - 50	Stiff	8 - 15	Sampler Type: S/S Size: 1 3/8" ID Automatic Hammer Weight: 140 lbs Safety Hammer Weight: Donut Hammer Weight: Fall: 30"
Very Dense	Over 50	Very Stiff	15 - 30	
N=Sum of Second and Third 6" Blow Counts		Hard	Over 30	
Terms Used for Second Entry of Descriptions: and = 40-50%, some = 10-40%, trace = 10% or less				Core Barrel Type: NX Size: 2.15" ID

**LAMSON ENGINEERING CORPORATION**

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Boring No. CWB-9

Page

1/1

Scale: 1" = 5'

City/Town: Wilmington				Bridge No.: W-38-003 (2NV)				Project File No.: 608929				Contract No.: -			
Location: Butters Row over MBTA/PAN AM Railroad								Date & Time Started: 11/9/22 8:00 AM						Total Hours:	
Groundwater Depth (Feet): 12.8' Date & Time: 11/9/22 2:00 PM								Date & Time Completed: 11/9/22 2:30 PM						6.5	
Coordinates: *N 3,021,429				*E 746,459				Ground Elevation (Feet): *95.8'				Inspector's Name: Edward Mahoney			
Drilling Company: New England Boring Contractors								Driller's Name: Mark D' Ambrosio				Helper's Name: Cody Richards			
Sample Number	Depth Range (Feet)	Blow Counts per 6 Inches				Recovery (inches)	Field Description						Strata Changes		
		Coring Times Minute Per Foot													
S-1	1' - 3'	16	8	7	8	13"	Rollerbit through 10" Asphalt						10"		
							Dry, medium dense, brown, FINE SAND, some fine to coarse gravel, some coarse sand.								
S-2	5' - 7'	10	6	1	3	5"	Dry, loose, brown, FINE TO COARSE SAND, trace fine to coarse gravel.								
S-3	10' - 12'	3	3	2	2	11"	Moist, loose, dark brown, FINE SAND, trace fine gravel, coarse sand.						14'		
S-4	15' - 17'	4	11	12	13	11"	Wet, medium dense, light brown, FINE SAND, trace inorganic silt, trace coarse sand.						19'		
S-5	20' - 22'	14	82	26	17	9"	Gray fine sand in wash water & top 6" of S-5						20'6"		
							Wet, very dense, gray, FINE SAND AND FINE TO COARSE GRAVEL, some inorganic silt, trace coarse sand.								
S-6	25' - 26'6"	15	9	6	60/ 0"	11"	Wet, medium dense, gray, FINE TO COARSE SAND, some fine to coarse gravel, some inorganic silt. Top of Bedrock @ 26'6"						26'6"		
C-1	26'6" - 27'8"	10	4/ 2"			14"	Fresh, hard, gray, GRANITE GNEISS						28'4"		
C-2	27'8" - 28'4"	12/ 8"					8"	Percent Recovery = 100% RQD = 14"/ 14" = 100% Fresh, hard, gray, GRANITE GNEISS Percent Recovery = 100% RQD = 8"/ 8" = 100%							
**Bottom of Exploration @ 28'4"															

Notes:

* Moved CWB-9 along guard rail towards bridge 4' and 3'6" further away from guard rail due to culvert. ** Terminated boring due to sufficient information (out of water/ end of day).

Arrow-Board: -

Signs: 2

Cones: 12

Protective Device Stand: - Box: -

Well Depth: - Solid Pipe: -

Stick Up Pipe: - Screen Pipe: -

Penetration Resistance (N) Guide:

Cohesionless Soils (Sands, Gravels)		Cohesive Soils (Silts, Clays)		Type of Drill Rig: Truck rig - GT8	
Relative Density	Penetration Resistance	Consistency	Penetration Resistance	Hammer Weight: 140 lbs	Fall: 30"
Very Loose	0 - 4	Very Soft	0 - 2	Casing Types: Drive	Spin
Loose	4 - 10	Soft	2 - 4	Size: HW(4")	NW(3")
Medium Dense	10 - 30	Medium Stiff	4 - 8	Depth: 20'	25'
Dense	30 - 50	Stiff	8 - 15	Sampler Type: S/S Size: 1 3/8" ID	
Very Dense	Over 50	Very Stiff	15 - 30	Automatic Hammer Weight: 140 lbs	
N=Sum of Second and Third 6" Blow Counts		Hard	Over 30	Safety Hammer Weight:	
Terms Used for Second Entry of Descriptions: and = 40-50%, some = 10-40%, trace = 10% or less				Donut Hammer Weight: Fall: 30"	
				Core Barrel Type: NX Size: 2.15" ID	

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Boring No. CWB-14Page
1/1

Scale: 1" = 5'

City/Town: Wilmington		Bridge No.: W-38-003 (2NV)		Project File No.: 608929		Contract No.: -		
Location: Butters Row over MBTA/PAN AM Railroad				Date & Time Started: 11/11/22 8:00 AM		Total Hours:		
Groundwater Depth (Feet): 15.5' Date & Time: 11/11/22 1:15 PM				Date & Time Completed: 11/11/22 2:00 PM		6.0		
Coordinates: *N 3,021,612		*E 746,585		Ground Elevation (Feet): *97.7'		Inspector's Name: Edward Mahoney		
Drilling Company: New England Boring Contractors				Driller's Name: Mark D' Ambrosio		Helper's Name: Cody Richards		
Sample Number	Depth Range (Feet)	Blow Counts per 6 Inches				Recovery (inches)	Field Description	Strata Changes
		Coring Times Minute Per Foot						
S-1	1' - 3'	10	9	9	5	12"	Rollerbit through 6" Asphalt Dry, medium dense, brown, FINE SAND, trace coarse sand, trace fine gravel.	6"
S-2	5' - 7'	3	2	2	1	15"	Dry, loose, light brown, FINE SAND.	
S-3	10' - 12'	5	3	3	4	14"	Moist, loose, light brown, FINE SAND, trace coarse sand.	13'
S-4	15' - 15'	60/ 0"				0"	Rollerbit hard	
C-1	15' - 19'	3.5	2	2	5	32"	Cored through 1' and 15" Boulders, coarse gravel.	19'
S-5	20' - 21'6"	82	47	56		6"	Wet, very dense, gray to black, FINE TO COARSE SAND AND FINE TO COARSE GRAVEL, trace inorganic silt.	
S-6	25' - 25'	60/ 0"				0"	Top of Bedrock @ 25'	25'
C-2	26' - 31'	3.5	4.5	4.5	5.5	58"	Rollerbit 25' to 26' Fresh, hard, slightly fractured, gray, DIORITE Percent Recovery = 58"/ 60" = 97% RQD = 58"/ 60" = 97%	
C-3	31' - 36'	5	4	4	4	5.5	60" Fresh, hard, slightly fractured, gray, DIORITE Percent Recovery = 60"/ 60" = 100% RQD = 60"/ 60" = 100%	36'
							Bottom of Exploration @ 36'	

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Boring No. WB-7Page
1/1

Scale: 1" = 5'

City/Town: Wilmington				Bridge No.: W-38-003 (2NV)				Project File No.: 608929				Contract No.: -			
Location: Butters Row over MBTA/PAN AM Railroad								Date & Time Started: *11/15/22 1:30 PM						Total Hours:	
Groundwater Depth (Feet): 5.9' Date & Time: 11/16/22 1:00 PM								Date & Time Completed: *11/16/22 2:00 PM						6.0	
Coordinates: **N 3,021,362 **E 746,360				Ground Elevation (Feet): 88.0'				Inspector's Name: Edward Mahoney							
Drilling Company: New England Boring Contractors								Driller's Name: Mark D' Ambrosio				Helper's Name: Cody Richards			
Sample Number	Depth Range (Feet)	Blow Counts per 6 Inches				Recovery (inches)	Field Description						Strata Changes		
		Coring Times Minute Per Foot													
S-1	0' - 2'	6	9	12	23	14"	6" Topsoil 6"								
							Dry, medium dense, brown, FINE TO COARSE SAND, some fine to medium gravel. (Fill Cobble/Boulder 0'-5')								
S-2	5' - 7'	4	7	10	12	14"	Wet, medium dense, brown, FINE SAND.						5'		
S-3	10' - 12'	3	4	4	6	13"	Wet, loose, light brown, FINE SAND.								
													13'6"		
S-4	14'6" - 16'6"	12	19	17	18	10"	Wet, dense, gray, FINE TO COARSE SAND, some fine to coarse gravel, trace inorganic silt.								
							Top of Bedrock @ 18'						18'		
C-1	18' - 23'	6.5	7.5	7.5	8.5	11	60"	Fresh, hard, slightly fractured, gray, DIORITE Percent Recovery = 60"/ 60" = 100% RQD = 55"/ 60" = 92%							
C-2	23' - 28'	6.5	7	8	8	7	60"	Fresh, hard, slightly fractured, gray, DIORITE Percent Recovery = 60"/ 60" = 100% RQD = 60"/ 60" = 100%						28'	
							Bottom of Exploration @ 28'								

Notes:

* Operation time: 11/15/22 1:30 PM to 2:30 PM, 11/16/22 9:00 AM to 2:00 PM.
 ** Moved boring WB-7 14' along alignment of wall towards CWB-6 due to setup.

 Arrow-Board: -
 Signs: 2
 Cones: 12

 Protective Device Stand: - Box: -
 Well Depth: - Solid Pipe: -
 Stick Up Pipe: - Screen Pipe: -
Penetration Resistance (N) Guide:

Cohesionless Soils (Sands, Gravels)		Cohesive Soils (Silts, Clays)		Type of Drill Rig: Truck rig - GT8
Relative Density	Penetration Resistance	Consistency	Penetration Resistance	Hammer Weight: 140 lbs Fall: 30"
Very Loose	0 - 4	Very Soft	0 - 2	Casing Types: Drive
Loose	4 - 10	Soft	2 - 4	Size: HW(4")
Medium Dense	10 - 30	Medium Stiff	4 - 8	Depth: 18'
Dense	30 - 50	Stiff	8 - 15	Sampler Type: S/S Size: 1 3/8" ID Automatic Hammer Weight: 140 lbs Safety Hammer Weight: Donut Hammer Weight: Fall: 30"
Very Dense	Over 50	Very Stiff	15 - 30	
N=Sum of Second and Third 6" Blow Counts		Hard	Over 30	
Terms Used for Second Entry of Descriptions: and = 40-50%, some = 10-40%, trace = 10% or less				Core Barrel Type: NX Size: 2.15" ID

**LAMSON ENGINEERING CORPORATION**
 437 Cherry Street, #109, Newton, Massachusetts 02465
 Phone: (617) 558-0101 E-Mail: Lamsoneng@msn.com
Boring No. WB-8Page
1/2

Scale: 1" = 5'

City/Town: Wilmington		Bridge No.: W-38-003 (2NV)				Project File No.: 608929			Contract No.: -		
Location: Butters Row over MBTA/PAN AM Railroad						Date & Time Started: 11/10/22 8:00 AM				Total Hours:	
Groundwater Depth (Feet): 15.3' Date & Time: 11/10/22 2:30 PM						Date & Time Completed: 11/10/22 3:00 PM				7.0	
Coordinates: *N 3,021,477		*E 746,496		Ground Elevation (Feet): *99.5'			Inspector's Name: Edward Mahoney				
Drilling Company: New England Boring Contractors					Driller's Name: Mark D' Ambrosio			Helper's Name: Cody Richards			
Sample Number	Depth Range (Feet)	Blow Counts per 6 Inches				Recovery (inches)	Field Description			Strata Changes	
		Coring Times Minute Per Foot									
S-1	1' - 3'	18	17	13	20	13"	Rollerbit through 12" Asphalt			12"	
							Dry, dense, brown, FINE TO COARSE SAND, some fine to medium gravel.				
S-2	5' - 7'	4	3	4	4	11"	Dry, loose, brown, FINE SAND, some fine to medium gravel, some coarse sand.				
S-3	10' - 12'	5	5	6	5	8"	Wet, medium dense, brown, FINE TO COARSE SAND AND FINE TO COARSE GRAVEL.				
S-4	15' - 17'	2	2	2	2	4"	Wet, very loose, brown, FINE SAND, trace coarse sand.				
										19'	
S-5	20' - 20'4"	100/ 4"				0"	No recovery				
							Rollerbit to 21'				
							Cored 21' to 24'6" through Cobbles/Boulders			24'6"	
S-6	24'6" - 26'6"	9	8	10	19	9"	Wet, medium dense, gray, FINE SAND, some coarse sand, some fine to medium gravel, some inorganic silt.				
S-7	29'6" - 31'6"	31	27	58	49	12"	Wet, very dense, gray, FINE TO COARSE GRAVEL AND FINE TO COARSE SAND, some inorganic silt.				
							Top of Bedrock @ 34'			34'	
C-1	34' - 39'	2	3.5	3.5	4.5	6	55"	Fresh, hard, gray, DIORITE Percent Recovery = 55"/ 60" = 92% RQD = 55"/ 60" = 92%			
C-2	39' - 42'2"	6.5	5	5.5	3/ 2"	38"	Fresh, hard, gray, DIORITE Percent Recovery = 38"/ 38" = 100% RQD = 38"/ 38" = 100%				
							Bottom of Exploration @ 42'2"			42'2"	



Boring Log

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Boring No. WB-8

Page
2/2

Scale: 1" = 5'

Sample Number	Depth Range (Feet)	Blow Counts per 6 Inches	Recovery (inches)	Field Description	Strata Changes
		Coring Times Minute Per Foot			

Notes:

* Moved WB-8 3.5' further away from guard rail due to setup.

Arrow-Board: -
Signs: 2
Cones: 12

Protective Device	Stand: -	Box: -
Well Depth: -	Solid Pipe: -	
Stick Up Pipe: -	Screen Pipe: -	

Penetration Resistance (N) Guide:

Type of Drill Rig:	Truck rig - GT8
--------------------	-----------------

Cohesionless Soils (Sands, Gravels)		Cohesive Soils (Silts, Clays)		Type of Soil: High: Working: Core	
Relative Density	Penetration Resistance	Consistency	Penetration Resistance	Hammer Weight: 140 lbs	Fall: 30"
Very Loose	0 - 4	Very Soft	0 - 2	Casing Types: Drive	Spin
Loose	4 - 10	Soft	2 - 4	Size: HW(4")	NW(3")
Medium Dense	10 - 30	Medium Stiff	4 - 8	Depth: 20'	34'
Dense	30 - 50	Stiff	8 - 15	Sampler Type: S/S	Size: 1 3/8" ID
Very Dense	Over 50	Very Stiff	15 - 30	Automatic Hammer Weight: 140 lbs	
N=Sum of Second and Third 6" Blow Counts		Hard	Over 30	Safety Hammer Weight:	
Terms Used for Second Entry of Descriptions: and = 40-50%, some = 10-40%, trace = 10% or less				Donut Hammer Weight:	Fall: 30"
				Core Barrel Type: NX	Size: 2.15" ID

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Boring No. WB-10Page
1/2

Scale: 1" = 5'

City/Town: Wilmington			Bridge No.: W-38-003 (2NV)			Project File No.: 608929			Contract No.: -		
Location: Butters Row over MBTA/PAN AM Railroad						Date & Time Started: 11/8/22 9:00 AM				Total Hours:	
Groundwater Depth (Feet): 9.3' Date & Time: 11/8/22 2:00 PM						Date & Time Completed: 11/8/22 2:30 PM				5.5	
Coordinates: N 3,021,364			E 746,406			Ground Elevation (Feet): 92.4'			Inspector's Name: Edward Mahoney		
Drilling Company: New England Boring Contractors					Driller's Name: Mark D' Ambrosio				Helper's Name: Cody Richards		
Sample Number	Depth Range (Feet)	Blow Counts per 6 Inches				Recovery (inches)	Field Description	Strata Changes			
		Coring Times Minute Per Foot									
S-1	1' - 3'	12	14	7	14	18"	Rollerbit through 10" Asphalt Dry, medium dense, dark brown, FINE SAND, some coarse sand, trace fine gravel.	14'			
S-2	5' - 7'	19	9	6	8	3"	Dry, medium dense, brown, FINE SAND, some coarse sand, trace fine gravel.				
S-3	10' - 12'	4	6	5	6	15"	Wet, medium dense, brown, FINE SAND.				
S-4	15' - 17'	26	20	14	12	8"	Wet, dense, gray/black, FINE TO COARSE SAND AND FINE TO COARSE GRAVEL, trace cobbles, trace inorganic silt.				
S-5	20' - 22'	24	23	29	92	14"	Wet, very dense, gray/black, FINE TO COARSE SAND AND FINE TO COARSE GRAVEL, trace inorganic silt. Top of Bedrock @ 22'6"				
C-1	23' - 28'	3.5	3.5	3	3	3.5	60"	Fresh, hard, gray, DIORITE Percent Recovery = 60"/ 60" = 100% RQD = 60"/ 60" = 100%	28'		
C-2	28' - 32'4"	3.5	3.5	3.5	3.5	3/ 4"	52"	Fresh, hard, gray, DIORITE Percent Recovery = 52"/ 52" = 100% RQD = 52"/ 52" = 100%	32'4"		
								Bottom of Exploration @ 32'4"			

Page
2/2

Scale: 1" = 5'

Notes:

Protective Device	Stand: -	Box: -
Well Depth: -	Solid Pipe: -	
Stick Up Pipe: -	Screen Pipe: -	

Type of Drill Rig:	Truck rig - GT8
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**LAMSON ENGINEERING CORPORATION**

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Boring No. WB-15Page
1/2

Scale: 1" = 5'

City/Town: Wilmington			Bridge No.: W-38-003 (2NV)			Project File No.: 608929			Contract No.: -		
Location: Butters Row over MBTA/PAN AM Railroad						Date & Time Started: 11/14/22 8:00 AM				Total Hours:	
Groundwater Depth (Feet): 15.4' Date & Time: 11/14/22 2:30 PM						Date & Time Completed: 11/14/22 2:45 PM				6.75	
Coordinates: *N 3,021,661			*E 746,600			Ground Elevation (Feet): *95.5'			Inspector's Name: Edward Mahoney		
Drilling Company: New England Boring Contractors					Driller's Name: Mark D' Ambrosio			Helper's Name: Cody Richards			
Sample Number	Depth Range (Feet)	Blow Counts per 6 Inches				Recovery (inches)	Field Description	Strata Changes			
		Coring Times Minute Per Foot									
S-1	1' - 3'	10	9	4	4	16"	Rollerbit through 12" Asphalt	12"			
							Dry, medium dense, brown, FINE SAND, some coarse sand, trace fine to medium gravel.				
S-2	5' - 7'	4	3	7	9	19"	Dry, medium dense, brown, FINE SAND, trace coarse sand, trace fine gravel, trace inorganic silt.				
S-3	10' - 12'	6	9	10	13	15"	Moist, medium dense, light brown, FINE SAND.				
S-4	15' - 17'	24	17	22	18	11"	Wet, dense, light brown, FINE TO COARSE SAND, some fine to coarse gravel, trace inorganic silt.				
S-5	20' - 22'	21	17	27	39	10"	Wet, dense, gray, FINE TO COARSE SAND AND FINE TO COARSE GRAVEL, trace inorganic silt.				
S-6	25' - 25'3"	60/ 3"	4.5	4	5	5.5	3	2"	Top of Bedrock @ 25'	25'	
								60"			
C-1	25'6" - 30'6"							Weathered Bedrock Fresh, hard, slightly fractured, gray, DIORITE Percent Recovery = 60"/ 60" = 100% RQD = 53"/ 60" = 88%			
C-2	30'6" - 34'6"	2	4	5.5	8	*35"	Fresh, hard, slightly fractured, gray, DIORITE Percent Recovery = *35"/ 48" = 73% * 12" of core left in hole RQD = 26"/ 48" = 54%				
							Bottom of Exploration @ 34'6"	34'6"			



Boring Log

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Boring No. WB-15

Page
2/2

Scale: 1" = 5'

Sample Number	Depth Range (Feet)	Blow Counts per 6 Inches	Recovery (inches)	Field Description	Strata Changes
		Coring Times Minute Per Foot			

Notes:

* Moved WB-15 2' futher away from guard rail due to setup.

Arrow-Board: -
Signs: 2
Cones: 12

Protective Device	Stand: -	Box: -
Well Depth: -	Solid Pipe: -	
Stick Up Pipe: -	Screen Pipe: -	

Penetration Resistance (N) Guide:

Type of Drill Rig:	Truck rig - GT8
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Cohesionless Soils (Sands, Gravels)		Cohesive Soils (Silts, Clays)		Hammer Weight: 140 lbs	Fall: 30"
Relative Density	Penetration Resistance	Consistency	Penetration Resistance	Casing Types: Drive	Spin
Very Loose	0 - 4	Very Soft	0 - 2	Size: HW(4")	NW(3")
Loose	4 - 10	Soft	2 - 4	Depth: 20'	25'6"
Medium Dense	10 - 30	Medium Stiff	4 - 8	Sampler Type: S/S	Size: 1 3/8" ID
Dense	30 - 50	Stiff	8 - 15	Automatic Hammer Weight: 140 lbs	
Very Dense	Over 50	Very Stiff	15 - 30	Safety Hammer Weight:	
N=Sum of Second and Third 6" Blow Counts		Hard	Over 30	Donut Hammer Weight:	Fall: 30"
Terms Used for Second Entry of Descriptions: and = 40-50%, some = 10-40%, trace = 10% or less				Core Barrel Type: NX	Size: 2.15" ID

APPENDIX 2

Calculations

INDEX OF CALCULATIONS

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LAMSON ENGINEERING CORPORATION		Final Page No:	
Project:	Bridge No. W-38-003, Wilmington	Job No:	Preliminary Sheet No:
Subject:	Wingwall Type 1 - 10.75 Dia. Micropile	Prepared by: SL	Date: 5/2023
Detail:	Summary of Micropile Resistance	Checked by: JG	Date: 5/2023

Summary of Micropile Resistance - Retaining Wall Types 1, 1A, & 1B

Steel Casing: 10.75 in. O.D. x 0.595 in., $F_y = 52$ ksi, Wall Thickness = 0.595 in.

Steel Reinforcing Bar: #14, Threaded, Grade 60

Compressive strength of micropile grout at 28 days: $f'_c = 5$ ksi

Rock Socket Diameter = 9.56 in.

Estimated Bonded Length into Rock (Grout into intact bedrock) = 5.5 ft.

Plunge Length (Casing into Intact Bedrock) = 1 ft

Nominal Geotechnical Pile Resistance per Pile = 297.3 kips

Side Resistance Factor, ϕ_{stat} = 0.55

Factored Geotechnical Pile Resistance per Pile = 163.5 kips > 98.6 k OK

Nominal Uplift Resistance per Pile = 148.7 kips

Resistance Factor, ϕ_{up} = 0.55

Factored Uplift Resistance per Pile = 81.8 kips > 29.4 k OK

Nominal Structural Pile Resistance per Pile = 1096.9 k (Portion of Cased Length)

Nominal Structural Pile Resistance per Pile = 366.0 k (Portion of Uncased Length)

Compression Resistance Factor, ϕ_C = 0.75

Factored Structural Pile Resistance per Pile = 822.7 k (Portion of Cased Length)

Factored Structural Pile Resistance per Pile = 274.5 k (Portion of Uncased Length)

LAMSON ENGINEERING CORPORATION		Final Page No:	
Project:	Bridge No. W-38-003, Wilmington	Job No:	Preliminary Sheet No:
Subject:	Wingwall Type 1 - 10.75 Dia. Micropile	Prepared by: SL	Date: 5/2023
Detail:	Summary of Micropile Resistance	Checked by: JG	Date: 5/2023

Nominal Tension Resistance = 995.0 k (Portion of Cased Length)

Nominal Tension Resistance = 135.1 k (Portion of Uncased Length)

Tension Resistance Factor, ϕ_T = 0.8

Factored Tension Resistance = 796.0 k (Portion of Cased Length)

Factored Tension Resistance = 108.1 k (Portion of Uncased Length)

LAMSON ENGINEERING CORPORATION		Final Page No:	
Project:	Bridge No. W-38-003, Wilmington	Job No:	Preliminary Sheet No:
Subject:	Wingwall Type 1 - 10.75 Dia. Micropile	Prepared by: SL	Date: 5/2023
Detail:	Micropile Vertical Resistance	Checked by: JG	Date: 5/2023

Axial Compression Resistance

Based on Boring BB-1 $O.D.$ = 10.75 in. t_{wall} = 0.595 in.

$$R_R = \text{Factored Resistance of a micropile}$$

$$= \phi R_n = \phi_{qp} R_p + \phi_{qs} R_s$$

in which:

$$R_p = q_p A_p$$

$$R_s = q_s A_s$$

where:

$$R_p = \text{nominal tip resistance}$$

(Per AASHTO C10.9.3.5.1, tip resistance is neglected for conservative)

$$R_s = \text{nominal grout to ground bond resistance}$$

$$\phi_{qp} = \text{resistance factor for tip resistance}$$

$$= 0.50 \quad (\text{AASHTO 10.5.5.2.5-1})$$

(Note: No tip resistance considered in this calculation)

$$\phi_{qs} = \text{resistance factor for grout-to-ground resistance}$$

$$= 0.55 \quad (\text{AASHTO 10.5.5.2.5-1})$$

$$d_p = \text{diameter of micropile tip}$$

$$= 9.56 \text{ in.}$$

$$A_p = \text{area of micropile tip} = \pi D^2/4$$

$$= 71.78 \text{ in.}^2 = 0.50 \text{ ft}^2$$

$$R_s = \pi d_b \alpha_b L_b$$

in which:

$$d_b = \text{diameter of micropile drill hole through bonded length}$$

$$= 9.56 \text{ in.} = 0.80 \text{ ft}$$

$$\alpha_b = \text{nominal micropile grout-to-ground bond strength}$$





$$= 21.6 \text{ ksf for Type A Diorite}$$

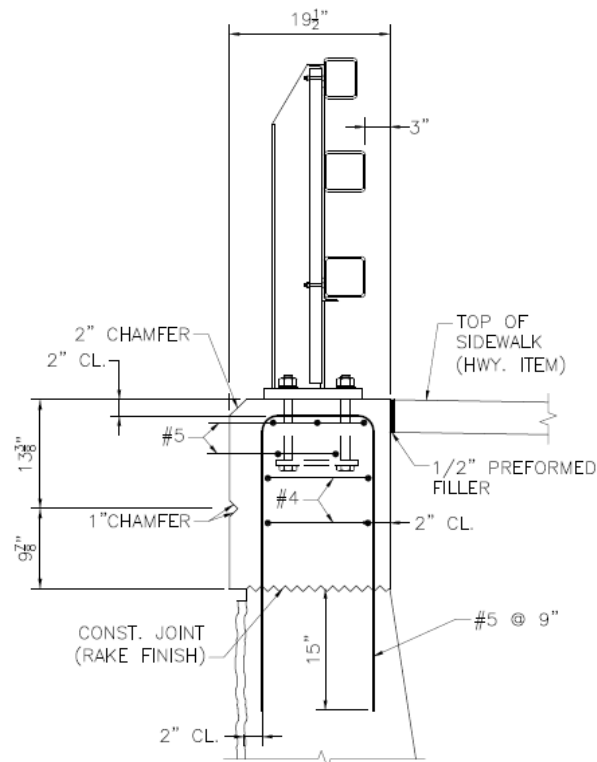
(AASHTO Table C10.9.3.5.2 - 1)

LAMSON ENGINEERING CORPORATION		Final Page No.:	
Project: Bridge No. W-38-003	Job No.:		Preliminary Sheet No.:
Subject: Retaining Wall 1	Prepared by: SL		Date: 5/2023
Detail: Unfactored Vertical Load	Checked by: JG		Date: 5/2023

Retaining Wall Type 1, 1A & 1B

Unfactored Vertical Load

	W (ft)	H (ft)	unit weight		
Coping	(1.63)	(1.94)	(0.15 kcf)	=	0.47 k/ft
Stem 	(1.54)	(17.58)	(0.15 kcf)	=	4.07 k/ft
Stem 	0.5 (1.47)	(17.58)	(0.15 kcf)	=	1.93 k/ft
Concrete Footing	(12.00)	(3.50)	(0.15 kcf)	=	6.30 k/ft
Vertical Soil 1 	0.5 (1.47)	(19.52)	(0.12 kcf)	=	1.72 k/ft
Vertical Soil 2 	(5.62)	(19.52)	(0.12 kcf)	=	13.16 k/ft
Bridge Railing S3-TL4 (DC)				=	0.090 k/ft



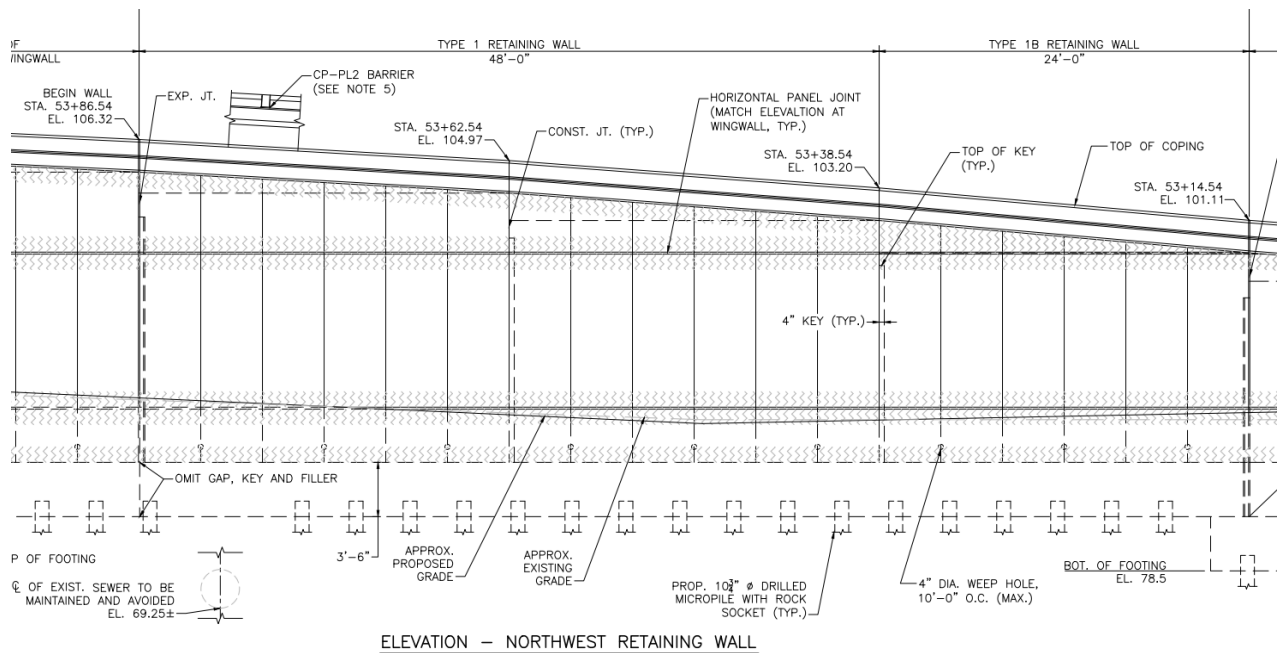
TOP OF U-WINGWALL/RETAINING WALL
DETAILS AT SIDEWALK

LAMSON ENGINEERING CORPORATION				Final Page No.:	
Project: Bridge No. W-38-003		Job No.:		Preliminary Sheet No.:	
Subject: Retaining Wall 1		Prepared by: SL		Date: 5/2023	
Detail: Unfactored Vertical Load		Checked by: JG		Date: 5/2023	

Retaining Wall Type 1, 1A & 1B

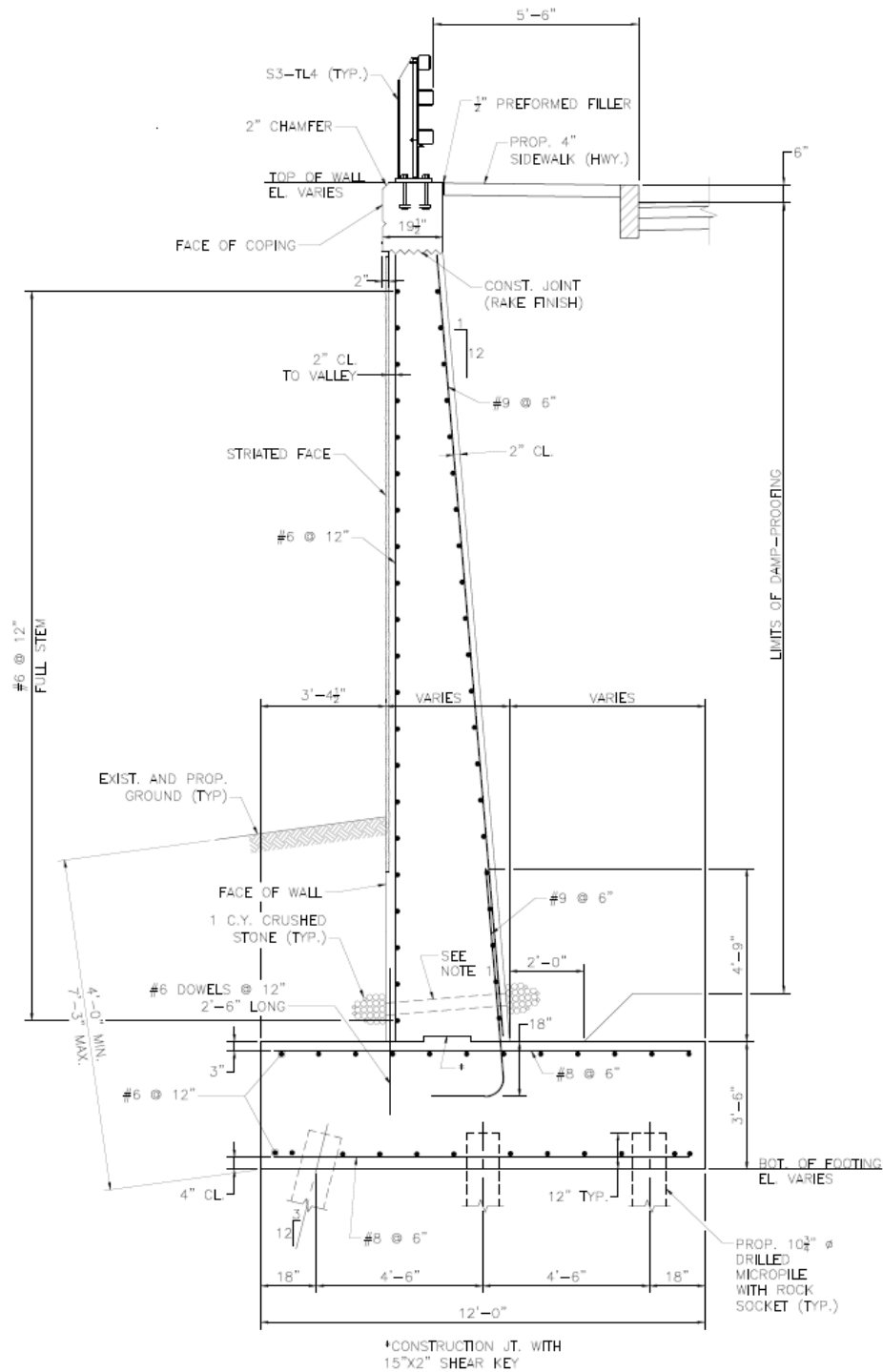
STA.	Elevation	STA.	Elevation	Length (ft.)	Bottom of Footing Elevation	Design H at highest 1/4 point (ft)	
54+90.19	107.48	55+10.84	106.8	23.0	86.50	20.81	SE Retaining Wall
53+86.54	106.32	53+14.54	101.11	72.0	82.00	23.02	NW Retaining Wall
54+97.65	107.27	55+68.70	103.36	72.0	83.50	22.79	NE Retaining Wall

By Investigations above, Northwest Retaining Wall could provide the control values for Micropile Design.



LAMSON ENGINEERING CORPORATION		Final Page No.:	
Project: Bridge No. W-38-003	Job No.:	Preliminary Sheet No.:	
Subject: Retaining Wall 1	Prepared by: SL	Date: 5/2023	
Detail: Unfactored Vertical Load	Checked by: JG	Date: 5/2023	

Retaining Wall Type 1, 1A & 1B



RETAINING WALL TYPE 1 TYPICAL SECTION

LAMSON ENGINEERING CORPORATION		Final Page No.:
Project: Bridge No. W-38-003	Job No.:	Preliminary Sheet No.:
Subject: Retaining Wall 1	Prepared by: SL	Date: 5/2023
Detail: Lateral earth pressure	Checked by: JG	Date: 5/2023

Determine Unfactored Horizontal Load

Effective angle of internal friction ϕ'_f	=	37	degree
Friction angle between fill and wall, δ	=	0	degree
Angle of fill to the horizontal, β	=	0.00	degree
Angle of back of wall to the horizontal, θ	=	90	degree
Unit weight of soil, γ_{soil}	=	0.125	kcf
Total unit weight of water, γ_w	=	0.0624	kcf
Height of Soil	=	23.02	ft ±
Distance from back of wall to footing heel, B_{heel}	=	7.08	ft
Height of fill behind footing at heel, $h = H + B_{\text{heel}} \tan \beta$	=	23.02	ft ±
Height of water from bottom of footing, H_w	=	0	ft

Lateral Earth Pressure (EH)

$$\text{Active pressure coefficient, } K_a = \frac{\sin^2(\theta + \phi'_f)}{\sin^2\theta \sin(\theta - \delta) \left[1 + \sqrt{\frac{\sin(\phi'_f + \delta) \sin(\phi'_f - \beta)}{\sin(\theta - \delta) \sin(\theta + \beta)}} \right]^2}$$

$$= 0.249$$

$$\text{At-rest pressure coefficient, } K_o = 1 - \sin \phi'_f = 1 - \sin(37)$$

$$= 0.398$$

Per *massDOT* LRFD BM 3.1.5

Founded on Pile = Y (Input Y if yes)

$$K_e = K_o = 0.398$$

$$= 0.398$$

$$\text{Lateral earth pressure, } P_{e1} = 0.5 K_e \gamma_{\text{soil}} (h - H_w)^2$$

$$= 0.5 \times 0.398 \times 0.125 \text{ kcf} \times (23.02 \text{ ft} - 0 \text{ ft})^2$$

$$= 13.19 \text{ k/ft length of wall}$$

$$\text{Vertical component of } P_{e1}, P_{ev1} = P_{e1} \sin(90 - \theta + \delta)$$

$$= 13.19 \text{ k/ft} \times \sin(90 - 90 + 0)$$

$$= 0.00 \text{ k/ft}$$

LAMSON ENGINEERING CORPORATION		Final Page No.:
Project: Bridge No. W-38-003	Job No.:	Preliminary Sheet No.:
Subject: Retaining Wall 1	Prepared by: SL	Date: 5/2023
Detail: Lateral earth pressure	Checked by: JG	Date: 5/2023

$$\begin{aligned}
 \text{Horizontal component of } P_{e1}, P_{eh1} &= P_{e1} \cos (90 - \theta + \delta) \\
 &= 13.19 \text{ k/ft} \times \cos (90 - 90 + 0) \\
 &= 13.19 \text{ k/ft}
 \end{aligned}$$

$$\begin{aligned}
 \text{Lateral earth pressure, } P_{e2} &= K_e \gamma_{\text{soil}} (h - H_w) H_w \\
 &= 0.398 \times 0.125 \text{ kcf} \times (23.02 \text{ ft} - 0 \text{ ft}) \times 0 \text{ ft} \\
 &= 0.00 \text{ k/ft length of wall}
 \end{aligned}$$

$$\begin{aligned}
 \text{Vertical component of } P_{e2}, P_{ev2} &= P_{e2} \sin (90 - \theta + \delta) \\
 &= 0 \text{ k/ft} \times \sin (90 - 90 + 0) \\
 &= 0.00 \text{ k/ft}
 \end{aligned}$$

$$\begin{aligned}
 \text{Horizontal component of } P_{e2}, P_{eh2} &= P_{e2} \cos (90 - \theta + \delta) \\
 &= 0 \text{ k/ft} \times \cos (90 - 90 + 0) \\
 &= 0.00 \text{ k/ft}
 \end{aligned}$$

$$\begin{aligned}
 \text{Lateral earth pressure, } P_{e3} &= 0.5 K_e \gamma' (H_w)^2 \\
 &= 0.5 \times 0.398 \times (0.125 \text{ kcf} - 0.0624 \text{ kcf}) \times 0 \text{ ft}^2 \\
 &= 0.00 \text{ k/ft length of wall}
 \end{aligned}$$

$$\begin{aligned}
 \text{Vertical component of } P_{e3}, P_{ev3} &= P_{e3} \sin (90 - \theta + \delta) \\
 &= 0 \text{ k/ft} \times \sin (90 - 90 + 0) \\
 &= 0.00 \text{ k/ft}
 \end{aligned}$$

$$\begin{aligned}
 \text{Horizontal component of } P_{e3}, P_{eh3} &= P_{e3} \cos (90 - \theta + \delta) \\
 &= 0 \text{ k/ft} \times \cos (90 - 90 + 0) \\
 &= 0.00 \text{ k/ft}
 \end{aligned}$$

LAMSON ENGINEERING CORPORATION		Final Page No.:
Project: Bridge No. W-38-003	Job No.:	Preliminary Sheet No.:
Subject: Retaining Wall 1	Prepared by: SL	Date: 5/2023
Detail: Lateral earth pressure	Checked by: JG	Date: 5/2023

Live Load Surcharge (LS) (AASHTO LRFD 3.11.6.4)

$$\text{Equivalent height of soil for , } h_{eq} = 2.000 \text{ ft}$$

$$\begin{aligned} \text{Vertical live load Surcharge on heel, LS} &= 0.125 \text{ kcf} \times 2 \text{ ft} \times 7.083 \text{ ft} \\ &= 1.771 \text{ k / ft} \end{aligned}$$

$$\begin{aligned} \text{Horizontal earth pressure due to live load surcharge } \Delta_p &= K_e \gamma_{\text{soil}} h_{eq} \\ &= 0.398 \times 0.125 \text{ kcf} \times 2 \text{ ft} \\ &= 0.10 \text{ ksf} \end{aligned}$$

$$\begin{aligned} \text{Live load lateral earth pressure, } P_{LS} &= \Delta_p h \\ &= 0.1 \text{ ksf} \times 23.02 \text{ ft} \\ &= 2.29 \text{ k/ft length of wall} \end{aligned}$$

$$\begin{aligned} \text{Vertical component of } P_{LS}, P_{LSV} &= P_{LS} \sin (90 - \alpha + \delta) \\ &= 2.29 \text{ k/ft} \times \sin (90 - 90 + 0) \\ &= 0.00 \text{ k/ft length of wall} \end{aligned}$$





$$\begin{aligned} \text{Horizontal component of } P_{LS}, P_{LSH} &= P_{LS} \cos (90 - \alpha + \delta) \\ &= 2.29 \text{ k/ft} \times \cos (90 - 90 + 0) \\ &= 2.29 \text{ k/ft length of wall} \end{aligned}$$

$$\begin{aligned} \text{Unfactored horizontal load, EH + LSH} &= P_{eh1} + P_{eh2} + P_{eh3} + P_{LSH} \\ &= 13.19 + 0 + 0 + 2.29 \\ &= \underline{15.48 \text{ k/ft length of wall}} \end{aligned}$$

LAMSON ENGINEERING CORPORATION			Final Page No.:	
Project:	Bridge No. W-38-003	Job No.:	Preliminary Sheet No.:	
Subject:	Retaining Wall 1	Prepared by: SL	Date: 5/2023	
Detail:	Strength I for Overturning	Checked by: JG	Date: 5/2023	

Summary of Factored Loads - Strength IA: 1.25DC + 1.35EH + 1.35EV + 1.75 LS

Vertical Loads and Vertical Moments

Item	Load Factor γ	Vertical load, V (k/ft)	Factored vertical load, V_u (k/ft)	Arm about ⌒ Footing	Factored Moment	
Coping	1.25	0.47	0.59	1.90	1.12	
Stem 	1.25	4.07	5.08	1.85	9.42	
Stem 	1.25	1.93	2.41	0.60	1.44	
Concrete Footing	1.25	6.30	7.88	0.00	0.00	
Vertical Soil 1 	1.35	1.72	2.32	0.11	0.25	
Vertical Soil 2 	1.35	13.16	17.77	-3.19	-56.69	
Bridge Railing	1.25	0.09	0.11	1.90	0.21	
P_{v1}	1.35	0.00	0.00	-6.00	0.00	
P_{v2}	1.35	0.00	0.00	-6.00	0.00	
P_{v3}	1.35	0.00	0.00	-6.00	0.00	
P_{LSV}	1.75	0.00	0.00	-6.00	0.00	
LS	1.75	1.77	3.10	-3.19	-9.89	
TOTAL		29.51	39.26		-54.14	ΣM_v

Horizontal Loads and Horizontal Moments

Item	Load Factor γ	Horizontal load H (k/ft)	Factored horizontal load, H_u (k/ft)	Arm about ⌒ Footing	Factored Moment	
P_{h1}	1.35	13.19	17.80	7.67	136.61	
P_{h2}	1.35	0.00	0.00	0.00	0.00	
P_{h3}	1.35	0.00	0.00	0.00	0.00	
P_{LSH}	1.75	2.29	4.01	11.51	46.16	
TOTAL		15.48	21.81		182.77	ΣM_H

LAMSON ENGINEERING CORPORATION				Final Page No.:	
Project: Bridge No. W-38-003, Wilmington		Job No.:		Preliminary Sheet No.:	
Subject: Retaining Wall 1		Prepared by: SL		Date: 5/2023	
Detail: Pile_STR I_VMAX		Checked by: JG		Date: 5/2023	

Pile STR I_VMAXCross Section = 0.63 ft.²

Number of Pile, n = 59

Length to Wall 72 ft

Factored Load at Bottom of Pile Cap Through Centroid of the Pile Group:

No. of Battered Pile = 20

Factored Horizontal Resistance (Front Piles battered 1:4) = 163.53 x 20 ea / 4 = 817.7 kips

Vertical, F_z = 2826.42 kipsF_y = 1570.6 - 817.67 = 752.93 kipsF_x = 0.00 kips

M_x = (-54.14+182.77) k-ft/ft x 72 ft + 2826.42 k x -0.08 ft
= 9045.88 k-ft

M_y = 0.00 kips-ft

Pile #	A _p (sf)	X _i (ft.)	Y _i (ft.)	A _p X _i (ft. ³)	A _p Y _i (ft. ³)	dx ² (X _i - X _{C.G}) ²	dy ² (Y _i - Y _{C.G}) ²	$\frac{M_x(Y_{C.G.} - Y_i)}{\sum (Y_i - Y_{C.G})^2}$	$\frac{M_y(X_{C.G.} - X_i)}{\sum (X_i - X_{C.G})^2}$	F _z / n	Σ F _z (kips)	Shear F _y / n	Shear F _x / n
1	0.63	0.00	-4.50	0.000	-2.836	1372.451	19.569	50.69	0.00	47.905	98.60	12.76	0.00
2	0.63	7.00	-4.50	4.412	-2.836	902.799	19.569	50.69	0.00	47.905	98.60	12.76	0.00
3	0.63	10.50	-4.50	6.618	-2.836	704.723	19.569	50.69	0.00	47.905	98.60	12.76	0.00
4	0.63	14.00	-4.50	8.824	-2.836	531.146	19.569	50.69	0.00	47.905	98.60	12.76	0.00
5	0.63	17.50	-4.50	11.030	-2.836	382.070	19.569	50.69	0.00	47.905	98.60	12.76	0.00
6	0.63	21.00	-4.50	13.236	-2.836	257.494	19.569	50.69	0.00	47.905	98.60	12.76	0.00
7	0.63	24.50	-4.50	15.442	-2.836	157.417	19.569	50.69	0.00	47.905	98.60	12.76	0.00
8	0.63	28.00	-4.50	17.648	-2.836	81.841	19.569	50.69	0.00	47.905	98.60	12.76	0.00
9	0.63	31.50	-4.50	19.854	-2.836	30.765	19.569	50.69	0.00	47.905	98.60	12.76	0.00
10	0.63	35.00	-4.50	22.060	-2.836	4.189	19.569	50.69	0.00	47.905	98.60	12.76	0.00
11	0.63	38.50	-4.50	24.266	-2.836	2.112	19.569	50.69	0.00	47.905	98.60	12.76	0.00
12	0.63	42.00	-4.50	26.472	-2.836	24.536	19.569	50.69	0.00	47.905	98.60	12.76	0.00
13	0.63	45.50	-4.50	28.678	-2.836	71.460	19.569	50.69	0.00	47.905	98.60	12.76	0.00
14	0.63	49.00	-4.50	30.884	-2.836	142.884	19.569	50.69	0.00	47.905	98.60	12.76	0.00
15	0.63	52.50	-4.50	33.091	-2.836	238.807	19.569	50.69	0.00	47.905	98.60	12.76	0.00
16	0.63	56.00	-4.50	35.297	-2.836	359.231	19.569	50.69	0.00	47.905	98.60	12.76	0.00
17	0.63	59.50	-4.50	37.503	-2.836	504.155	19.569	50.69	0.00	47.905	98.60	12.76	0.00
18	0.63	63.00	-4.50	39.709	-2.836	673.578	19.569	50.69	0.00	47.905	98.60	12.76	0.00
19	0.63	66.50	-4.50	41.915	-2.836	867.502	19.569	50.69	0.00	47.905	98.60	12.76	0.00
20	0.63	69.42	-4.50	43.753	-2.836	1047.821	19.569	50.69	0.00	47.905	98.60	12.76	0.00
1	0.63	0.00	0.00	0.000	0.000	1372.451	0.006	-0.87	0.00	47.905	47.03	12.76	0.00
2	0.63	7.00	0.00	4.412	0.000	902.799	0.006	-0.87	0.00	47.905	47.03	12.76	0.00
3	0.63	10.50	0.00	6.618	0.000	704.723	0.006	-0.87	0.00	47.905	47.03	12.76	0.00
4	0.63	14.00	0.00	8.824	0.000	531.146	0.006	-0.87	0.00	47.905	47.03	12.76	0.00
5	0.63	17.50	0.00	11.030	0.000	382.070	0.006	-0.87	0.00	47.905	47.03	12.76	0.00
6	0.63	21.00	0.00	13.236	0.000	257.494	0.006	-0.87	0.00	47.905	47.03	12.76	0.00
7	0.63	24.50	0.00	15.442	0.000	157.417	0.006	-0.87	0.00	47.905	47.03	12.76	0.00
8	0.63	28.00	0.00	17.648	0.000	81.841	0.006	-0.87	0.00	47.905	47.03	12.76	0.00
9	0.63	31.50	0.00	19.854	0.000	30.765	0.006	-0.87	0.00	47.905	47.03	12.76	0.00
10	0.63	35.00	0.00	22.060	0.000	4.189	0.006	-0.87	0.00	47.905	47.03	12.76	0.00
11	0.63	38.50	0.00	24.266	0.000	2.112	0.006	-0.87	0.00	47.905	47.03	12.76	0.00
12	0.63	42.00	0.00	26.472	0.000	24.536	0.006	-0.87	0.00	47.905	47.03	12.76	0.00
13	0.63	45.50	0.00	28.678	0.000	71.460	0.006	-0.87	0.00	47.905	47.03	12.76	0.00
14	0.63	49.00	0.00	30.884	0.000	142.884	0.006	-0.87	0.00	47.905	47.03	12.76	0.00
15	0.63	52.50	0.00	33.091	0.000	238.807	0.006	-0.87	0.00	47.905	47.03	12.76	0.00
16	0.63	56.00	0.00	35.297	0.000	359.231	0.006	-0.87	0.00	47.905	47.03	12.76	0.00
17	0.63	59.50	0.00	37.503	0.000	504.155	0.006	-0.87	0.00	47.905	47.03	12.76	0.00
18	0.63	63.00	0.00	39.709	0.000	673.578	0.006	-0.87	0.00	47.905	47.03	12.76	0.00
19	0.63	66.50	0.00	41.915	0.000	867.502	0.006	-0.87	0.00	47.905	47.03	12.76	0.00
20	0.63	69.42	0.00	43.753	0.000	1047.821	0.006	-0.87	0.00	47.905	47.03	12.76	0.00
1	0.63	0.00	4.50	0.000	2.836	1372.451	20.942	-52.44	0.00	47.905	-4.53	12.76	0.00
2	0.63	10.50	4.50	6.62	2.836	704.72	20.94	-52.44	0.00	47.91	-4.53	12.76	0.00
3	0.63	14.00	4.50	8.824	2.836	531.146	20.942	-52.44	0.00	47.905	-4.53	12.76	0.00
4	0.63	17.50	4.50	11.030	2.836	382.070	20.942	-52.44	0.00	47.905	-4.53	12.76	0.00
5	0.63	21.00	4.50	13.236	2.836	257.494	20.942	-52.44	0.00	47.905	-4.53	12.76	0.00
6	0.63	24.50	4.50	15.442	2.836	157.417	20.942	-52.44	0.00	47.905	-4.53	12.76	0.00
7	0.63	28.00	4.50	17.648	2.836	81.841	20.942	-52.44	0.00	47.905	-4.53	12.76	0.00
8	0.63	31.50	4.50	19.854	2.836	30.765	20.942	-52.44	0.00	47.905	-4.53	12.76	0.00

LAMSON ENGINEERING CORPORATION				Final Page No.:	
Project: Bridge No. W-38-003, Wilmington		Job No.:		Preliminary Sheet No.:	
Subject: Retaining Wall 1		Prepared by: SL		Date: 5/2023	
Detail: Pile_STR I_VMAX		Checked by: JG		Date: 5/2023	

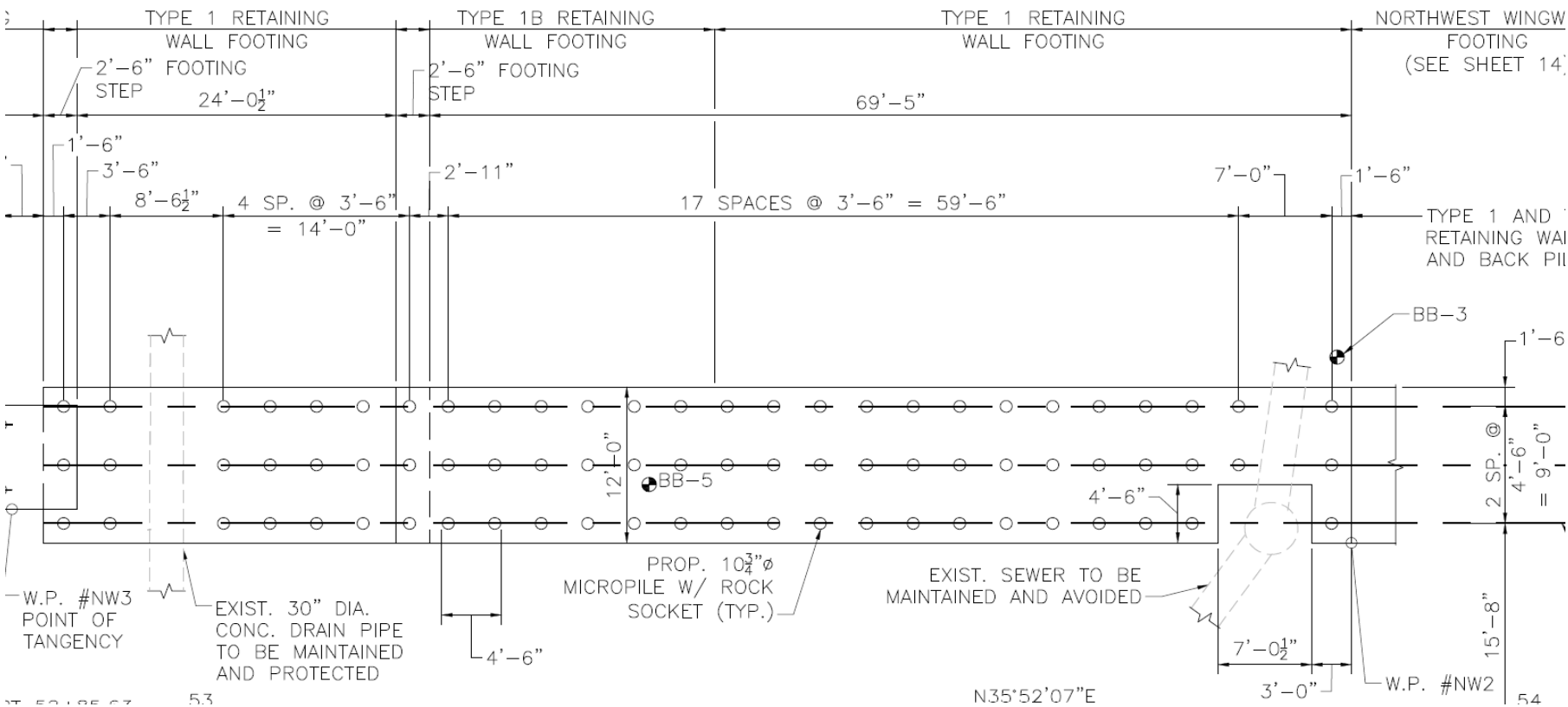
Pile STR I VMAX

9	0.63	35.00	4.50	22.060	2.836	4.189	20.942	-52.44	0.00	47.905	-4.53	12.76	0.00
10	0.63	38.50	4.50	24.266	2.836	2.112	20.942	-52.44	0.00	47.905	-4.53	12.76	0.00
11	0.63	42.00	4.50	26.472	2.836	24.536	20.942	-52.44	0.00	47.905	-4.53	12.76	0.00
12	0.63	45.50	4.50	28.678	2.836	71.460	20.942	-52.44	0.00	47.905	-4.53	12.76	0.00
13	0.63	49.00	4.50	30.884	2.836	142.884	20.942	-52.44	0.00	47.905	-4.53	12.76	0.00
14	0.63	52.50	4.50	33.091	2.836	238.807	20.942	-52.44	0.00	47.905	-4.53	12.76	0.00
15	0.63	56.00	4.50	35.297	2.836	359.231	20.942	-52.44	0.00	47.905	-4.53	12.76	0.00
16	0.63	59.50	4.50	37.503	2.836	504.155	20.942	-52.44	0.00	47.905	-4.53	12.76	0.00
17	0.63	63.00	4.50	39.709	2.836	673.578	20.942	-52.44	0.00	47.905	-4.53	12.76	0.00
18	0.63	66.50	4.50	41.915	2.836	867.502	20.942	-52.44	0.00	47.905	-4.53	12.76	0.00
19	0.63	69.42	4.50	43.753	2.836	1047.821	20.942	-52.44	0.00	47.905	-4.53	12.76	0.00
59	37.19			1377.67	-2.84					98.60	12.76		
										-4.53	12.76		

$X_{C.G.} = \Sigma A_p X_i / \Sigma A_p = 1377.67 / 37.19 = 37.047 \text{ ft.}$ $Y_{C.G.} = \Sigma A_p Y_i / \Sigma A_p = -2.84 / 37.19 = -0.076 \text{ ft.}$ from Pile Cap Center

$\Sigma (X_i - X_{C.G.})^2 = 24168 \text{ ft.}^2$ $\Sigma (Y_i - Y_{C.G.})^2 = 789.41 \text{ ft.}^2$

Resultant Shear on Single Pile = $(12.76^2 + 0.00^2)^{0.5} = 12.76 \text{ kips}$



LAMSON ENGINEERING CORPORATION			Final Page No.:	
Project: Bridge No. W-38-003	Job No.:		Preliminary Sheet No.:	
Subject: Retaining Wall 1	Prepared by: SL		Date: 5/2023	
Detail: Strength I for Sliding and Eccentricity	Checked by: JG		Date: 5/2023	

Summary of Factored Loads - Strength IB: 0.90DC + 1.35EH + 1.0EV + 1.75 LS

Vertical Loads and Vertical Moments

Item	Load Factor γ	Vertical load, V (k/ft)	Factored vertical load, V_u (k/ft)	Arm about CL Footing	Factored Moment	
Coping	0.90	0.47	0.43	1.90	0.81	
Stem	0.90	4.07	3.66	1.85	6.78	
Stem	0.90	1.93	1.74	0.60	1.03	
Concrete Footing	0.90	6.30	5.67	0.00	0.00	
Vertical Soil 1	1.00	1.72	1.72	0.11	0.18	
Vertical Soil 2	1.00	13.16	13.16	-3.19	-41.99	
Bridge Railing	0.90	0.09	0.08	1.90	0.15	
P_{v1}	1.35	0.00	0.00	-6.00	0.00	
P_{v2}	1.35	0.00	0.00	-6.00	0.00	
P_{v3}	1.35	0.00	0.00	-6.00	0.00	
P_{LSV}	1.75	0.00	0.00	-6.00	0.00	
LS	1.75	0.00	0.00	-3.19	0.00	
TOTAL		27.74	26.45		-33.03	ΣM_v

Horizontal Loads and Horizontal Moments

Item	Load Factor γ	Horizontal load H (k/ft)	Factored horizontal load, H_u (k/ft)	Arm about CL Footing	Factored Moment	
P_{h1}	1.35	13.19	17.80	7.67	136.61	
P_{h2}	1.35	0.00	0.00	0.00	0.00	
P_{h3}	1.35	0.00	0.00	0.00	0.00	
P_{LSH}	1.75	2.29	4.01	11.51	46.16	
TOTAL		15.48	21.81		182.77	ΣM_H

LAMSON ENGINEERING CORPORATION				Final Page No.:	
Project: Bridge No. W-38-003, Wilmington		Job No.:		Preliminary Sheet No.:	
Subject: Retaining Wall 1		Prepared by: SL		Date: 5/2023	
Detail: Pile_STR I_VMIN		Checked by: JG		Date: 5/2023	

Pile STR I VMIN

Cross Section = 0.63 ft.²

Number of Pile, n = 59

Length between Expansion Joints = 72 ft

Factored Load at Bottom of Pile Cap Through Centroid of the Pile Group:

No. of Battered Pile = 20

Factored Horizontal Resistance (Front Piles battered 1:4) = 163.53 x 20 ea / 4 = 817.7 kips

Vertical, F_z = 1904.36 kips

F_y = 1570.6 - 817.67 = 752.93 kips

F_x = 0.00 kips

M_x = (-33.03+182.77) k-ft/ft x 72 ft + 1904.36 k x -0.08 ft
= 10635.98 k-ft

M_y = 0.00 kips-ft

Pile #	A _p (sf)	X _i (ft.)	Y _i (ft.)	A _p X _i (ft. ³)	A _p Y _i (ft. ³)	dx ² (X _i - X _{C.G.}) ²	dy ² (Y _i - Y _{C.G.}) ²	$\frac{M_x(Y_{C.G.} - Y_i)}{\sum (Y_i - Y_{C.G.})^2}$	$\frac{M_y(X_{C.G.} - X_i)}{\sum (X_i - X_{C.G.})^2}$	F _z / n	Σ F _z (kips)	Shear F _y / n	Shear F _x / n
1	0.63	0.00	-4.50	0.000	-2.836	1372.451	19.569	59.60	0.00	32.277	91.88	12.76	0.00
2	0.63	7.00	-4.50	4.412	-2.836	902.799	19.569	59.60	0.00	32.277	91.88	12.76	0.00
3	0.63	10.50	-4.50	6.618	-2.836	704.723	19.569	59.60	0.00	32.277	91.88	12.76	0.00
4	0.63	14.00	-4.50	8.824	-2.836	531.146	19.569	59.60	0.00	32.277	91.88	12.76	0.00
5	0.63	17.50	-4.50	11.030	-2.836	382.070	19.569	59.60	0.00	32.277	91.88	12.76	0.00
6	0.63	21.00	-4.50	13.236	-2.836	257.494	19.569	59.60	0.00	32.277	91.88	12.76	0.00
7	0.63	24.50	-4.50	15.442	-2.836	157.417	19.569	59.60	0.00	32.277	91.88	12.76	0.00
8	0.63	28.00	-4.50	17.648	-2.836	81.841	19.569	59.60	0.00	32.277	91.88	12.76	0.00
9	0.63	31.50	-4.50	19.854	-2.836	30.765	19.569	59.60	0.00	32.277	91.88	12.76	0.00
10	0.63	35.00	-4.50	22.060	-2.836	4.189	19.569	59.60	0.00	32.277	91.88	12.76	0.00
11	0.63	38.50	-4.50	24.266	-2.836	2.112	19.569	59.60	0.00	32.277	91.88	12.76	0.00
12	0.63	42.00	-4.50	26.472	-2.836	24.536	19.569	59.60	0.00	32.277	91.88	12.76	0.00
13	0.63	45.50	-4.50	28.678	-2.836	71.460	19.569	59.60	0.00	32.277	91.88	12.76	0.00
14	0.63	49.00	-4.50	30.884	-2.836	142.884	19.569	59.60	0.00	32.277	91.88	12.76	0.00
15	0.63	52.50	-4.50	33.091	-2.836	238.807	19.569	59.60	0.00	32.277	91.88	12.76	0.00
16	0.63	56.00	-4.50	35.297	-2.836	359.231	19.569	59.60	0.00	32.277	91.88	12.76	0.00
17	0.63	59.50	-4.50	37.503	-2.836	504.155	19.569	59.60	0.00	32.277	91.88	12.76	0.00
18	0.63	63.00	-4.50	39.709	-2.836	673.578	19.569	59.60	0.00	32.277	91.88	12.76	0.00
19	0.63	66.50	-4.50	41.915	-2.836	867.502	19.569	59.60	0.00	32.277	91.88	12.76	0.00
20	0.63	69.42	-4.50	43.753	-2.836	1047.821	19.569	59.60	0.00	32.277	91.88	12.76	0.00
1	0.63	0.00	0.00	0.000	0.000	1372.451	0.006	-1.03	0.00	32.277	31.25	12.76	0.00
2	0.63	7.00	0.00	4.412	0.000	902.799	0.006	-1.03	0.00	32.277	31.25	12.76	0.00
3	0.63	10.50	0.00	6.618	0.000	704.723	0.006	-1.03	0.00	32.277	31.25	12.76	0.00
4	0.63	14.00	0.00	8.824	0.000	531.146	0.006	-1.03	0.00	32.277	31.25	12.76	0.00
5	0.63	17.50	0.00	11.030	0.000	382.070	0.006	-1.03	0.00	32.277	31.25	12.76	0.00
6	0.63	21.00	0.00	13.236	0.000	257.494	0.006	-1.03	0.00	32.277	31.25	12.76	0.00
7	0.63	24.50	0.00	15.442	0.000	157.417	0.006	-1.03	0.00	32.277	31.25	12.76	0.00
8	0.63	28.00	0.00	17.648	0.000	81.841	0.006	-1.03	0.00	32.277	31.25	12.76	0.00
9	0.63	31.50	0.00	19.854	0.000	30.765	0.006	-1.03	0.00	32.277	31.25	12.76	0.00
10	0.63	35.00	0.00	22.060	0.000	4.189	0.006	-1.03	0.00	32.277	31.25	12.76	0.00
11	0.63	38.50	0.00	24.266	0.000	2.112	0.006	-1.03	0.00	32.277	31.25	12.76	0.00
12	0.63	42.00	0.00	26.472	0.000	24.536	0.006	-1.03	0.00	32.277	31.25	12.76	0.00
13	0.63	45.50	0.00	28.678	0.000	71.460	0.006	-1.03	0.00	32.277	31.25	12.76	0.00
14	0.63	49.00	0.00	30.884	0.000	142.884	0.006	-1.03	0.00	32.277	31.25	12.76	0.00
15	0.63	52.50	0.00	33.091	0.000	238.807	0.006	-1.03	0.00	32.277	31.25	12.76	0.00
16	0.63	56.00	0.00	35.297	0.000	359.231	0.006	-1.03	0.00	32.277	31.25	12.76	0.00
17	0.63	59.50	0.00	37.503	0.000	504.155	0.006	-1.03	0.00	32.277	31.25	12.76	0.00
18	0.63	63.00	0.00	39.709	0.000	673.578	0.006	-1.03	0.00	32.277	31.25	12.76	0.00
19	0.63	66.50	0.00	41.915	0.000	867.502	0.006	-1.03	0.00	32.277	31.25	12.76	0.00
20	0.63	69.42	0.00	43.753	0.000	1047.821	0.006	-1.03	0.00	32.277	31.25	12.76	0.00
1	0.63	0.00	4.50	0.000	2.84	1372.451	20.942	-61.66	0.00	32.277	-29.38	12.76	0.00
2	0.63	10.50	4.50	6.618	2.84	704.723	20.942	-61.66	0.00	32.277	-29.38	12.76	0.00
3	0.63	14.00	4.50	8.82	2.84	531.15	20.94	-61.66	0.00	32.28	-29.38	12.76	0.00
4	0.63	17.50	4.50	11.03	2.84	382.07	20.94	-61.66	0.00	32.28	-29.38	12.76	0.00
5	0.63	21.00	4.50	13.24	2.84	257.49	20.94	-61.66	0.00	32.28	-29.38	12.76	0.00
6	0.63	24.50	4.50	15.44	2.84	157.42	20.94	-61.66	0.00	32.28	-29.38	12.76	0.00
7	0.63	28.00	4.50	17.65	2.84	81.84	20.94	-61.66	0.00	32.28	-29.38	12.76	0.00
8	0.63	31.50	4.50	19.85	2.84	30.76	20.94	-61.66	0.00	32.28	-29.38	12.76	0.00

LAMSON ENGINEERING CORPORATION				Final Page No.:	
Project: Bridge No. W-38-003, Wilmington		Job No.:		Preliminary Sheet No.:	
Subject: Retaining Wall 1		Prepared by: SL		Date: 5/2023	
Detail: Pile_STR I_VMIN		Checked by: JG		Date: 5/2023	

Pile STR I VMIN

9	0.63	35.00	4.50	22.06	2.84	4.19	20.94	-61.66	0.00	32.28	-29.38	12.76	0.00
10	0.63	38.50	4.50	24.27	2.84	2.11	20.94	-61.66	0.00	32.28	-29.38	12.76	0.00
11	0.63	42.00	4.50	26.47	2.84	24.54	20.94	-61.66	0.00	32.28	-29.38	12.76	0.00
12	0.63	45.50	4.50	28.68	2.84	71.46	20.94	-61.66	0.00	32.28	-29.38	12.76	0.00
13	0.63	49.00	4.50	30.88	2.84	142.88	20.94	-61.66	0.00	32.28	-29.38	12.76	0.00
14	0.63	52.50	4.50	33.09	2.84	238.81	20.94	-61.66	0.00	32.28	-29.38	12.76	0.00
15	0.63	56.00	4.50	35.30	2.84	359.23	20.94	-61.66	0.00	32.28	-29.38	12.76	0.00
16	0.63	59.50	4.50	37.50	2.84	504.15	20.94	-61.66	0.00	32.28	-29.38	12.76	0.00
17	0.63	63.00	4.50	39.71	2.84	673.58	20.94	-61.66	0.00	32.28	-29.38	12.76	0.00
18	0.63	66.50	4.50	41.91	2.84	867.50	20.94	-61.66	0.00	32.28	-29.38	12.76	0.00
19	0.63	69.42	4.50	43.75	2.84	1047.82	20.94	-61.66	0.00	32.28	-29.38	12.76	0.00
59	37.19			1377.67	-2.84						91.88	12.76	
											-29.38	12.76	

$$X_{C.G.} = \Sigma A_p X_i / \Sigma A_p = 1377.67 / 37.19 = 37.047 \text{ ft.} \quad Y_{C.G.} = \Sigma A_p Y_i / \Sigma A_p = -2.84 / 37.19 = -0.076 \text{ ft.}$$

$$\Sigma (X_i - X_{C.G.})^2 = 24168 \text{ ft.}^2 \quad \Sigma (Y_i - Y_{C.G.})^2 = 789.41 \text{ ft.}^2$$

$$\text{Resultant Shear on Single Pile} = (12.76^2 + 0.00^2)^{0.5} = 12.76 \text{ kips}$$

LAMSON ENGINEERING CORPORATION		Final Page No.:
Project: Bridge No. W-38-003	Job No.:	Preliminary Sheet No.:
Subject: Retaining Wall 1	Prepared by: SL	Date: 5/2023
Detail: Service I for Settlement	Checked by: JG	Date: 5/2023

Summary of Factored Loads - Service I: 1.0DC + 1.0EH + 1.0EV

Vertical Loads and Vertical Moments

Item	Load Factor γ	Vertical load, V (k/ft)	Factored vertical load, V_u (k/ft)	Arm about CL Footing	Factored Moment
Coping	1.00	0.47	0.47	1.90	0.90
Stem	1.00	4.07	4.07	1.85	7.54
Stem	1.00	1.93	1.93	0.60	1.15
Concrete Footing	1.00	6.30	6.30	0.00	0.00
Vertical Soil 1	1.00	1.72	1.72	0.11	0.18
Vertical Soil 2	1.00	13.16	13.16	-3.19	-41.99
Bridge Railing	1.00	0.09	0.09	1.90	0.17
P_{v1}	1.00	0.00	0.00	-6.00	0.00
P_{v2}	1.00	0.00	0.00	-6.00	0.00
P_{v3}	1.00	0.00	0.00	-6.00	0.00
P_{LSV}	1.00	0.00	0.00	-6.00	0.00
LS	1.00	1.77	1.77	-3.19	-5.65
TOTAL		29.51	29.51		-37.71

ΣM_v

Horizontal Loads and Horizontal Moments

Item	Load Factor γ	Horizontal load H (k/ft)	Factored horizontal load, H_u (k/ft)	Arm about CL Footing	Factored Moment
P_{h1}	1.00	13.19	13.19	7.67	101.20
P_{h2}	1.00	0.00	0.00	0.00	0.00
P_{h3}	1.00	0.00	0.00	0.00	0.00
P_{LSH}	1.00	2.29	2.29	11.51	26.38
TOTAL		15.48	15.48		127.57

ΣM_H

LAMSON ENGINEERING CORPORATION				Final Page No.:	
Project: Bridge No. W-38-003, Wilmington		Job No.:		Preliminary Sheet No.:	
Subject: Retaining Wall 1		Prepared by: SL		Date: 5/2023	
Detail: Pile_SERVICE I		Checked by: JG		Date: 5/2023	

Pile_SERVICE ICross Section = 0.63 ft.²

Number of Pile, n = 59

Length to Expansion Joint = 72 ft

Factored Load at Bottom of Pile Cap Through Centroid of the Pile Group:

No. of Battered Pile = 20

Factored Horizontal Resistance (Front Piles battered 1:4) = 163.53 x 20 ea / 4 = 817.7 kips

Vertical, F_z = 2124.45 kipsF_y = 1114.52 - 817.67 = 296.86 kipsF_x = 0.00 kips

M_x = (-37.71+127.57) k-ft/ft x 72 ft + 2124.45 k x -0.08 ft
= 6308.18 k-ft

M_y = 0.00 kips-ft

Pile #	A _p (sf)	X _i (ft.)	Y _i (ft.)	A _p X _i (ft. ³)	A _p Y _i (ft. ³)	dx ² (X _i - X _{C.G.}) ²	dy ² (Y _i - Y _{C.G.}) ²	$\frac{M_x(Y_{C.G.} - Y_i)}{\sum (Y_i - Y_{C.G.})^2}$	$\frac{M_y(X_{C.G.} - X_i)}{\sum (X_i - X_{C.G.})^2}$	F _z / n	Σ F _z (kips)	Shear F _y / n	Shear F _x / n
1	0.63	0.00	-4.50	0.000	-2.836	1372.451	19.569	35.35	0.00	36.008	71.36	5.03	0.00
2	0.63	7.00	-4.50	4.412	-2.836	902.799	19.569	35.35	0.00	36.008	71.36	5.03	0.00
3	0.63	10.50	-4.50	6.618	-2.836	704.723	19.569	35.35	0.00	36.008	71.36	5.03	0.00
4	0.63	14.00	-4.50	8.824	-2.836	531.146	19.569	35.35	0.00	36.008	71.36	5.03	0.00
5	0.63	17.50	-4.50	11.030	-2.836	382.070	19.569	35.35	0.00	36.008	71.36	5.03	0.00
6	0.63	21.00	-4.50	13.236	-2.836	257.494	19.569	35.35	0.00	36.008	71.36	5.03	0.00
7	0.63	24.50	-4.50	15.442	-2.836	157.417	19.569	35.35	0.00	36.008	71.36	5.03	0.00
8	0.63	28.00	-4.50	17.648	-2.836	81.841	19.569	35.35	0.00	36.008	71.36	5.03	0.00
9	0.63	31.50	-4.50	19.854	-2.836	30.765	19.569	35.35	0.00	36.008	71.36	5.03	0.00
10	0.63	35.00	-4.50	22.060	-2.836	4.189	19.569	35.35	0.00	36.008	71.36	5.03	0.00
11	0.63	38.50	-4.50	24.266	-2.836	2.112	19.569	35.35	0.00	36.008	71.36	5.03	0.00
12	0.63	42.00	-4.50	26.472	-2.836	24.536	19.569	35.35	0.00	36.008	71.36	5.03	0.00
13	0.63	45.50	-4.50	28.678	-2.836	71.460	19.569	35.35	0.00	36.008	71.36	5.03	0.00
14	0.63	49.00	-4.50	30.884	-2.836	142.884	19.569	35.35	0.00	36.008	71.36	5.03	0.00
15	0.63	52.50	-4.50	33.091	-2.836	238.807	19.569	35.35	0.00	36.008	71.36	5.03	0.00
16	0.63	56.00	-4.50	35.297	-2.836	359.231	19.569	35.35	0.00	36.008	71.36	5.03	0.00
17	0.63	59.50	-4.50	37.503	-2.836	504.155	19.569	35.35	0.00	36.008	71.36	5.03	0.00
18	0.63	63.00	-4.50	39.709	-2.836	673.578	19.569	35.35	0.00	36.008	71.36	5.03	0.00
19	0.63	66.50	-4.50	41.915	-2.836	867.502	19.569	35.35	0.00	36.008	71.36	5.03	0.00
20	0.63	69.42	-4.50	43.753	-2.836	1047.821	19.569	35.35	0.00	36.008	71.36	5.03	0.00
1	0.63	0.00	0.00	0.000	0.000	1372.451	0.006	-0.61	0.00	36.008	35.40	5.03	0.00
2	0.63	7.00	0.00	4.412	0.000	902.799	0.006	-0.61	0.00	36.008	35.40	5.03	0.00
3	0.63	10.50	0.00	6.618	0.000	704.723	0.006	-0.61	0.00	36.008	35.40	5.03	0.00
4	0.63	14.00	0.00	8.824	0.000	531.146	0.006	-0.61	0.00	36.008	35.40	5.03	0.00
5	0.63	17.50	0.00	11.030	0.000	382.070	0.006	-0.61	0.00	36.008	35.40	5.03	0.00
6	0.63	21.00	0.00	13.236	0.000	257.494	0.006	-0.61	0.00	36.008	35.40	5.03	0.00
7	0.63	24.50	0.00	15.442	0.000	157.417	0.006	-0.61	0.00	36.008	35.40	5.03	0.00
8	0.63	28.00	0.00	17.648	0.000	81.841	0.006	-0.61	0.00	36.008	35.40	5.03	0.00
9	0.63	31.50	0.00	19.854	0.000	30.765	0.006	-0.61	0.00	36.008	35.40	5.03	0.00
10	0.63	35.00	0.00	22.060	0.000	4.189	0.006	-0.61	0.00	36.008	35.40	5.03	0.00
11	0.63	38.50	0.00	24.266	0.000	2.112	0.006	-0.61	0.00	36.008	35.40	5.03	0.00
12	0.63	42.00	0.00	26.472	0.000	24.536	0.006	-0.61	0.00	36.008	35.40	5.03	0.00
13	0.63	45.50	0.00	28.678	0.000	71.460	0.006	-0.61	0.00	36.008	35.40	5.03	0.00
14	0.63	49.00	0.00	30.884	0.000	142.884	0.006	-0.61	0.00	36.008	35.40	5.03	0.00
15	0.63	52.50	0.00	33.091	0.000	238.807	0.006	-0.61	0.00	36.008	35.40	5.03	0.00
16	0.63	56.00	0.00	35.297	0.000	359.231	0.006	-0.61	0.00	36.008	35.40	5.03	0.00
17	0.63	59.50	0.00	37.503	0.000	504.155	0.006	-0.61	0.00	36.008	35.40	5.03	0.00
18	0.63	63.00	0.00	39.709	0.000	673.578	0.006	-0.61	0.00	36.008	35.40	5.03	0.00
19	0.63	66.50	0.00	41.915	0.000	867.502	0.006	-0.61	0.00	36.008	35.40	5.03	0.00
20	0.63	69.42	0.00	43.753	0.000	1047.821	0.006	-0.61	0.00	36.008	35.40	5.03	0.00
1	0.63	0.00	4.50	0.000	2.836	1372.451	20.942	-36.57	0.00	36.008	-0.56	5.03	0.00
2	0.63	10.50	4.50	6.618	2.836	704.723	20.942	-36.57	0.00	36.008	-0.56	5.03	0.00
3	0.63	14.00	4.50	8.824	2.836	531.146	20.942	-36.57	0.00	36.008	-0.56	5.03	0.00
4	0.63	17.50	4.50	11.030	2.836	382.070	20.942	-36.57	0.00	36.008	-0.56	5.03	0.00
5	0.63	21.00	4.50	13.236	2.836	257.494	20.942	-36.57	0.00	36.008	-0.56	5.03	0.00
6	0.63	24.50	4.50	15.442	2.836	157.417	20.942	-36.57	0.00	36.008	-0.56	5.03	0.00
7	0.63	28.00	4.50	17.648	2.836	81.841	20.942	-36.57	0.00	36.008	-0.56	5.03	0.00
8	0.63	31.50	4.50	19.854	2.836	30.765	20.942	-36.57	0.00	36.008	-0.56	5.03	0.00

LAMSON ENGINEERING CORPORATION				Final Page No.:	
Project: Bridge No. W-38-003, Wilmington		Job No.:		Preliminary Sheet No.:	
Subject: Retaining Wall 1		Prepared by: SL		Date: 5/2023	
Detail: Pile_SERVICE I		Checked by: JG		Date: 5/2023	

Pile_SERVICE I

9	0.63	35.00	4.50	22.060	2.836	4.189	20.942	-36.57	0.00	36.008	-0.56	5.03	0.00
10	0.63	38.50	4.50	24.266	2.836	2.112	20.942	-36.57	0.00	36.008	-0.56	5.03	0.00
11	0.63	42.00	4.50	26.472	2.836	24.536	20.942	-36.57	0.00	36.008	-0.56	5.03	0.00
12	0.63	45.50	4.50	28.678	2.836	71.460	20.942	-36.57	0.00	36.008	-0.56	5.03	0.00
13	0.63	49.00	4.50	30.884	2.836	142.884	20.942	-36.57	0.00	36.008	-0.56	5.03	0.00
14	0.63	52.50	4.50	33.091	2.836	238.807	20.942	-36.57	0.00	36.008	-0.56	5.03	0.00
15	0.63	56.00	4.50	35.297	2.836	359.231	20.942	-36.57	0.00	36.008	-0.56	5.03	0.00
16	0.63	59.50	4.50	37.503	2.836	504.155	20.942	-36.57	0.00	36.008	-0.56	5.03	0.00
17	0.63	63.00	4.50	39.709	2.836	673.578	20.942	-36.57	0.00	36.008	-0.56	5.03	0.00
18	0.63	66.50	4.50	41.915	2.836	867.502	20.942	-36.57	0.00	36.008	-0.56	5.03	0.00
19	0.63	69.42	4.50	43.753	2.836	1047.821	20.942	-36.57	0.00	36.008	-0.56	5.03	0.00
59	37.19			1377.67	-2.84						71.36	5.03	
											-0.56	5.03	

$$X_{C.G.} = \Sigma A_p X_i / \Sigma A_p = 1377.67 / 37.19 = 37.047 \text{ ft.} \quad Y_{C.G.} = \Sigma A_p Y_i / \Sigma A_p = 2.84 / 37.19 = -0.076 \text{ ft.}$$

$$\Sigma (X_i - X_{C.G.})^2 = 24168 \text{ ft.}^2 \quad \Sigma (Y_i - Y_{C.G.})^2 = 789.41 \text{ ft.}^2$$

$$\text{Resultant Shear on Single Pile} = (5.03^2 + 0.00^2)^{0.5} = 5.03 \text{ kips}$$

LAMSON ENGINEERING CORPORATION		Final Page No:	
Project:	Bridge No. W-38-003, Wilmington	Job No:	Preliminary Sheet No:
Subject:	Wingwall Type 1 - 10.75 Dia. Micropile	Prepared by: SL	Date: 12/2022
Detail:	Micropile Vertical Resistance	Checked by: JG	Date: 12/2022

Axial Compression Resistance

Based on Boring BB-1 $O.D.$ = 10.75 in. t_{wall} = 0.595 in.

$$R_R = \text{Factored Resistance of a micropile}$$

$$= \phi R_n = \phi_{qp} R_p + \phi_{qs} R_s$$

in which:

$$R_p = q_p A_p$$

$$R_s = q_s A_s$$

where:

$$R_p = \text{nominal tip resistance}$$

(Per AASHTO C10.9.3.5.1, tip resistance is neglected for conservative)

$$R_s = \text{nominal grout to ground bond resistance}$$

$$\phi_{qp} = \text{resistance factor for tip resistance}$$

$$= 0.50 \quad (\text{AASHTO 10.5.5.2.5-1})$$

$$\phi_{qs} = \text{resistance factor for grout-to-ground resistance}$$

$$= 0.55 \quad (\text{AASHTO 10.5.5.2.5-1})$$

$$d_p = \text{diameter of micropile tip}$$

$$= 9.56 \text{ in.}$$

$$A_p = \text{area of micropile tip} = \pi D^2/4$$

$$= 71.78 \text{ in.}^2 = 0.50 \text{ ft}^2$$

$$R_s = \pi d_b \alpha_b L_b$$

in which:

$$d_b = \text{diameter of micropile drill hole through bonded length}$$

$$= 9.56 \text{ in.} = 0.80 \text{ ft}$$

$$\alpha_b = \text{nominal micropile grout-to-ground bond strength}$$

$$= 21.6 \text{ ksf for Type A Diorite}$$

(AASHTO Table C10.9.3.5.2 - 1)

LAMSON ENGINEERING CORPORATION		Final Page No:	
Project:	Bridge No. W-38-003, Wilmington	Job No:	Preliminary Sheet No:
Subject:	Wingwall Type 1 - 10.75 Dia. Micropile	Prepared by: SL	Date: 5/2023
Detail:	Micropile Vertical Resistance	Checked by: JG	Date: 5/2023

$$L_b = \text{micropile bonded length}$$

$$= 5.5 \text{ ft into Intact Bedrock}$$

$$\phi_{qs} R_s = 0.55 \times 3.141 \times 0.8 \times [21.6 \times 5.5]$$

$$= 163.5 \text{ kips}$$

$$R_n = 163.53 / 0.55 = \underline{297 \text{ kips}}$$

$$R_R = \underline{164 \text{ kips}}$$

Uplift Resistance

$$\text{Uplift Resistance} = 50 \% \text{ of the compression resistance}$$

$$= 0.5 \times 163.5 = \underline{82 \text{ kips}}$$

$$\phi_{up} = \text{resistance factor}$$

$$= 0.55$$

$$\text{Nominal Resistance} = 81.8 / 0.55 = \underline{149 \text{ kips}}$$

Structural Resistance

Axial Compression Resistance

$$R_C = \text{Factored Structural Resistance of a micropile}$$

$$= \phi_c R_n$$

in which:

$$\phi_c = \text{resistance factor for tip resistance}$$

$$= 0.75 \quad (\text{AASHTO 10.5.5.2.5-2})$$

$$R_n = \text{Nominal axial compression resistance}$$

• For the cased length

$$F_y = 52 \text{ ksi}$$

$$f_y = 60 \text{ ksi} \quad (\text{Reinforcing Bar Grade 60})$$

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Subject:	Wingwall Type 1 - 10.75 Dia. Micropile	Prepared by: SL	Date: 5/2023
Detail:	Micropile Vertical Resistance	Checked by: JG	Date: 5/2023

$$R_n = 0.85 [0.85 f'_c A_g + f_y (A_b + A'_c)]$$

where:

$$f'_c = \text{specified compressive strength of micropile grout at 28 days}$$

$$= 5.0 \text{ ksi}$$

$$f_y = \text{specified minimum yield strength of reinforcement bar or steel casing, or stress in steel reinforcement bar or casing at a strain of 0.003, whichever is less}$$

$$\text{Min. } (F_y, f_y) = 52.0 \text{ ksi}$$

$$d_b = 1.69 \text{ in. } \#14 \text{ threaded bar}$$

$$A_b = \text{cross-section area of steel reinforcing bar}$$

$$= 2.25 \text{ in.}^2$$

$$A_c = \text{cross-section area of steel casing}$$

$$= 18.98 \text{ in.}^2$$

$$A'_c = \text{cross-section area of steel casing with 1/16" section loss on outside of the casing}$$

$$= 16.9 \text{ in.}^2 \quad \text{Section loss} = 0.063 \text{ in.}$$

$$A_g = \text{cross-section area of grout within micropile}$$

$$= A_{ID} - A_b = 71.78 - 2.25$$

$$= 69.53 \text{ in.}^2$$

$$R_n = 0.85 \times [0.85 \times 5 \times 69.53 + 52 \times (2.25 + 16.88)]$$

$$= 1096.9 \text{ kips}$$

$$R_{CC} = 0.75 \times 1096.9 = \underline{823 \text{ kips}}$$

• For the uncased length

$$R_n = 0.85 [0.85 f'_c A_g + f_y A_b]$$

$$f_y = \text{specified minimum yield strength of reinforcement bar or stress in steel reinforcement bar at a strain of 0.003, whichever is less}$$

$$= 60.0 \text{ ksi}$$

$$= 60 \text{ ksi}$$

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Project:	Bridge No. W-38-003, Wilmington	Job No:	Preliminary Sheet No:	
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Detail:	Micropile Vertical Resistance	Checked by:	JG	Date: 5/2023

$$R_n = 0.85 \times [0.85 \times 5 \times 69.53 + 60 \times 2.25]$$

$$= 366.0 \quad \text{kips}$$

$$R_{CU} = 0.75 \times 366 = \underline{274 \quad \text{kips}}$$

Axial Tension Resistance

$$R_T = \text{factored Structural Resistance of a micropile}$$

$$= \phi_T R_n$$

in which:

$$\phi_T = \text{resistance factor for tip resistance}$$

$$= 0.80 \quad (\text{AASHTO 10.5.5.2.5-2})$$

$$R_n = \text{nominal axial tension resistance}$$

• For the cased length

$$R_n = f_y (A_b + A'_c)$$

$$= 52 \times (2.25 + 16.88) = 995.0 \quad \text{kips}$$

$$R_{TC} = 0.8 \times 995 = \underline{796 \quad \text{kips}}$$

• For the uncased length

$$R_n = f_y A_b$$

$$= 60 \times 2.25 = 135.1 \quad \text{kips}$$

$$R_{TU} = 0.8 \times 135.1 = \underline{108 \quad \text{kips}}$$

LAMSON ENGINEERING CORPORATION		Final Page No:	
Project:	Bridge No. W-38-003, Wilmington	Job No:	Preliminary Sheet No:
Subject:	Wingwall Micropile Foundation	Prepared by: SL	Date: 5/2023
Detail:	Lpile Analysis	Checked by: JG	Date: 5/2023

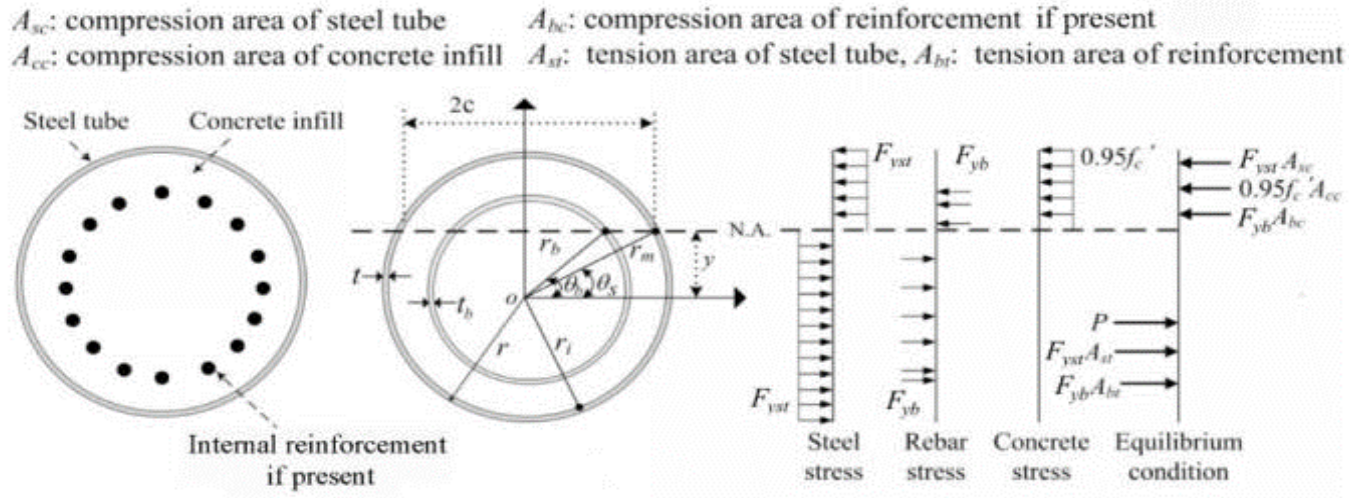


Figure C6.12.2.3.3-1—PSDM Model

$$\begin{aligned}
 P_n &= F_{yst} t r_m \left[(\pi - 2\theta_s) - (\pi + 2\theta_s) \right] \\
 &+ t_b r_b \left[F_{yb} (\pi - 2\theta_b) - (F_{yb} - 0.95 f'_c) (\pi + 2\theta_b) \right] \\
 &+ \frac{0.95 f'_c}{2} \left[(\pi - 2\theta_s) r_i^2 - 2yc \right]
 \end{aligned}
 \tag{C6.12.2.3.3-1}$$

$$M_n = 0.95 f'_c c \left[(r_i^2 - y^2) - \frac{c^2}{3} \right] + 4 F_{yst} t c \frac{r_m^2}{r_i} + 4 F_{yb} t_b c_b r_b
 \tag{C6.12.2.3.3-2}$$

in which:

$$r_m = r - \frac{t}{2}
 \tag{C6.12.2.3.3-3}$$

$$\theta_s = \sin^{-1} \left(\frac{y}{r_m} \right)
 \tag{C6.12.2.3.3-4}$$

$$\theta_b = \sin^{-1} \left(\frac{y}{r_b} \right)
 \tag{C6.12.2.3.3-5}$$

$$c = r_i \cos \theta_s
 \tag{C6.12.2.3.3-6}$$

$$c_b = r_b \cos \theta_b
 \tag{C6.12.2.3.3-7}$$

$$t_b = \frac{n A_b}{2 \pi r_b}
 \tag{C6.12.2.3.3-8}$$

LAMSON ENGINEERING CORPORATION			Final Page No:	
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Detail:	Lpile Analysis	Checked by: JG	Date:	5/2023

Yield Strength, $F_{yst} = 52.00$ ksi
 Strength of Concrete, $f'_c = 5.00$ ksi
 Resistance factor for CFST in compression, $\phi_c = 0.90$ (AASHTO 6.5.4.2)
 Yield Strength, $F_{yb} = 60.00$ ksi
 (AASHTO 6.9.6.2 Limitations) $D/t = 20.0 < 0.15 E / F_{yst} = 83.7$ **OK**
 Concrete shall be greater than 3 ksi or $0.075 F_{yst} = 3.9$ ksi < 5.00 ksi **OK**

$A_s = 2.25$ in² Cover = 3.934 in.
 $r = 5.313$ in. $t = 0.5325$ in.
 $r_m = 5.046$ in.
 $r_i = 4.780$ in.
 $r_b = 0.000$ in. Internal reinforcement is not considered.
 Number of reinforcing bars, $n = 1.0$
 $t_b = n A_s / (2 \pi r_b) = 0$ in.

Strength I

Factored Moment = 64.7 k-ft from Lpile
 Factored Axial Load = 98.6 k from Lpile

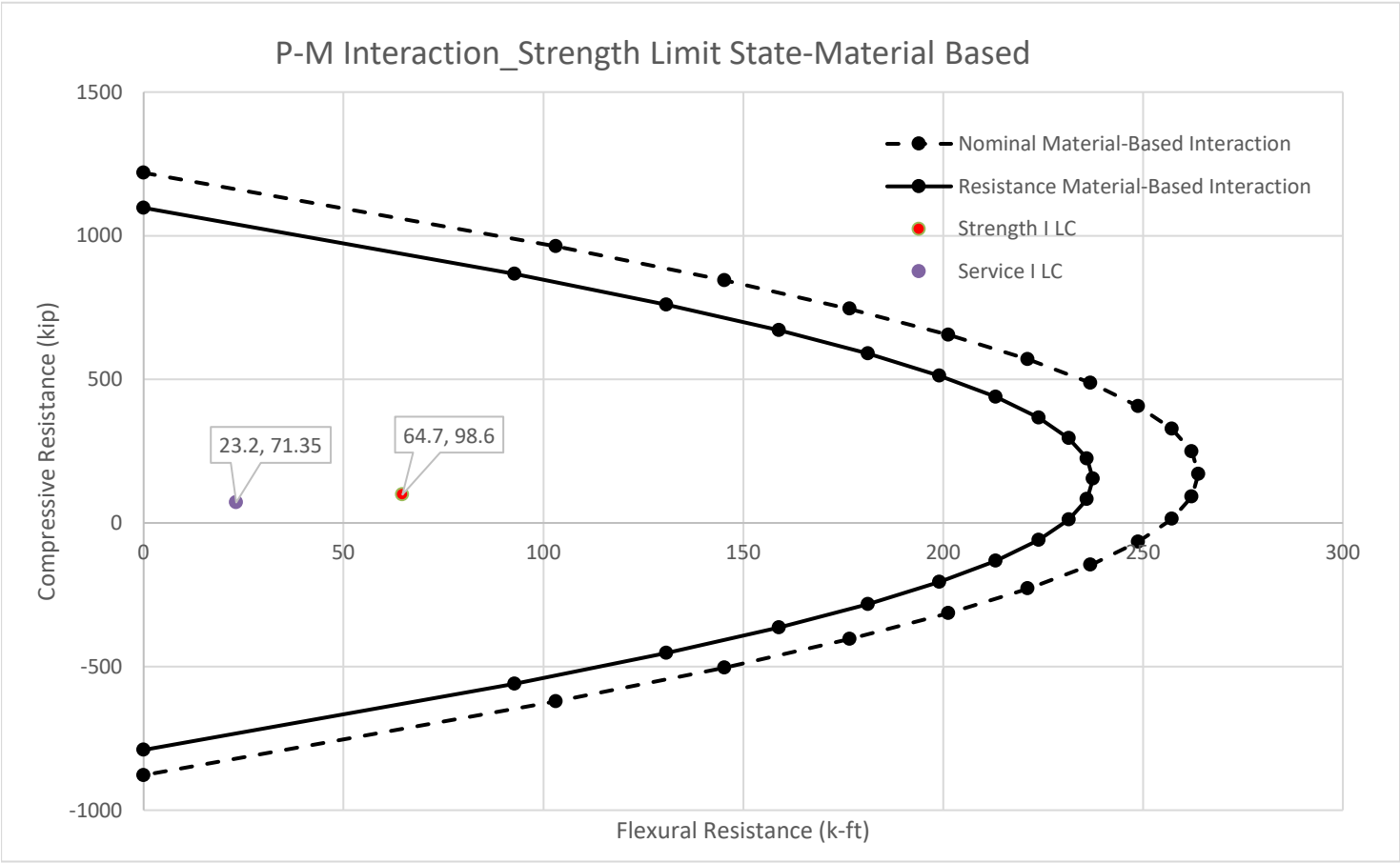
Service I

Factored Moment = 23.2 k-ft from Lpile
 Factored Axial Load = 71.35 k from Lpile

Composite Concrete-Filled Steel Tubes (CFSTs) (AASHTO LRFD 6.12.2.3.3)

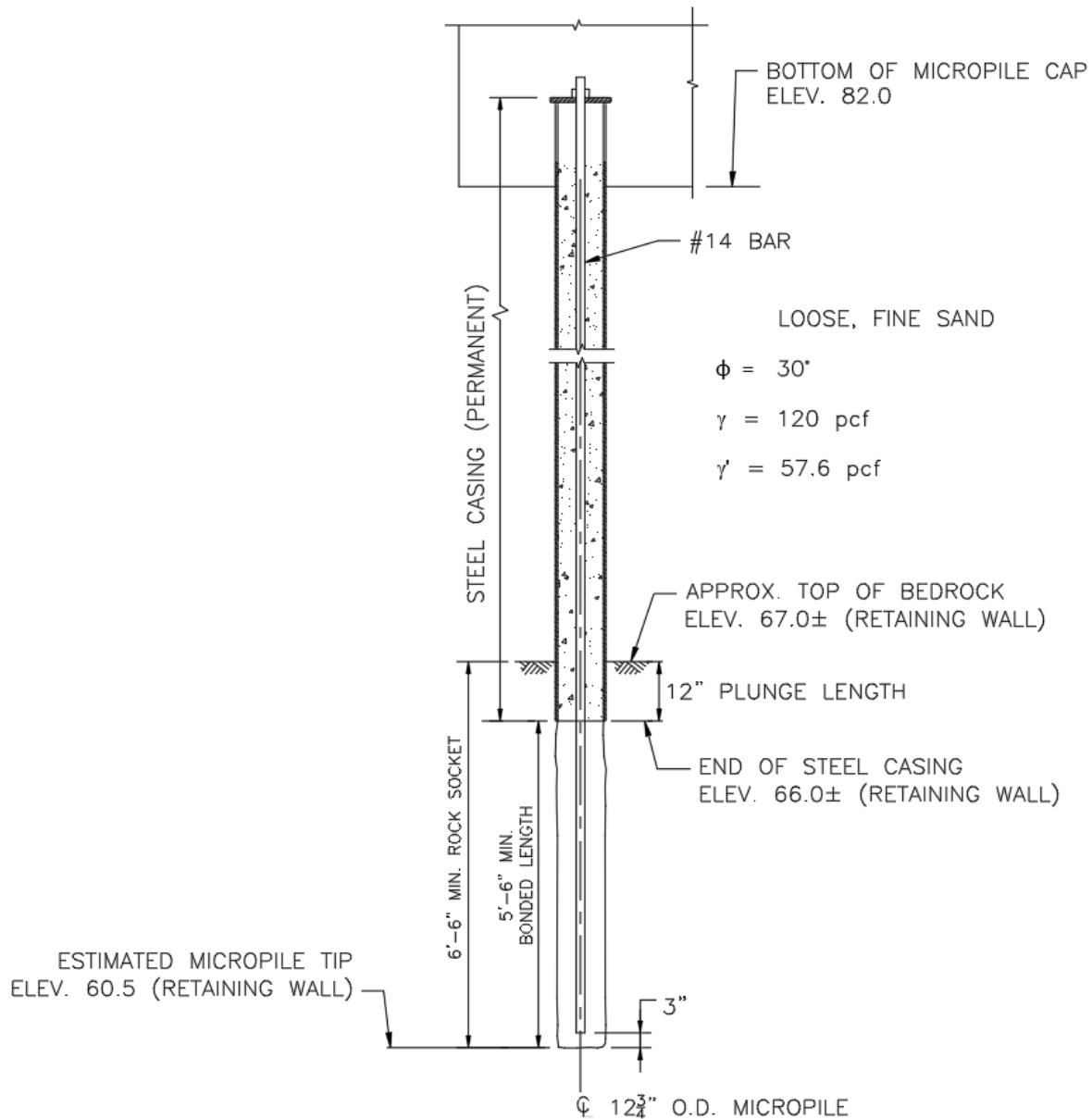
y (in.)	θ_s (rad)	θ_b (rad)	$c = r_i \cos \theta_b$	$c_b = r_b \cos \theta_b$	$\pi - 2 \theta_s$	$\pi + 2 \theta_s$	M_n (kips-ft)	P_n (kips)	$\phi_c M_n$ (kips-ft)	$\phi_c P_n$ (kips)
-5.05	-1.57	-1.57	0.00	0.00	6.28	0.00	0.00	1218.91	0.00	1097.02
-4.54	-1.12	-1.57	2.08	0.00	5.38	0.90	103.09	962.82	92.78	866.54
-4.04	-0.93	-1.57	2.87	0.00	5.00	1.29	145.35	844.40	130.81	759.96
-3.53	-0.78	-1.57	3.41	0.00	4.69	1.59	176.62	745.30	158.95	670.77
-3.03	-0.64	-1.57	3.82	0.00	4.43	1.85	201.36	654.98	181.23	589.48
-2.52	-0.52	-1.57	4.14	0.00	4.19	2.09	221.20	569.57	199.08	512.61
-2.02	-0.41	-1.57	4.38	0.00	3.96	2.32	236.88	487.15	213.19	438.44
-1.51	-0.30	-1.57	4.56	0.00	3.75	2.53	248.81	406.64	223.93	365.97
-1.01	-0.20	-1.57	4.68	0.00	3.54	2.74	257.20	327.33	231.48	294.59
-0.50	-0.10	-1.57	4.76	0.00	3.34	2.94	262.20	248.74	235.98	223.86
0.00	0.00	1.57	4.78	0.00	3.14	3.14	263.86	170.48	237.47	153.43
0.50	0.10	1.57	4.76	0.00	2.94	3.34	262.20	92.22	235.98	83.00
1.01	0.20	1.57	4.68	0.00	2.74	3.54	257.20	13.63	231.48	12.27
1.51	0.30	1.57	4.56	0.00	2.53	3.75	248.81	-65.68	223.93	-59.11
2.02	0.41	1.57	4.38	0.00	2.32	3.96	236.88	-146.19	213.19	-131.57
2.52	0.52	1.57	4.14	0.00	2.09	4.19	221.20	-228.61	199.08	-205.75
3.03	0.64	1.57	3.82	0.00	1.85	4.43	201.36	-314.02	181.23	-282.62
3.53	0.78	1.57	3.41	0.00	1.59	4.69	176.62	-404.34	158.95	-363.90
4.04	0.93	1.57	2.87	0.00	1.29	5.00	145.35	-503.44	130.81	-453.10
4.54	1.12	1.57	2.08	0.00	0.90	5.38	103.09	-621.86	92.78	-559.68
5.05	1.57	1.57	0.00	0.00	0.00	6.28	0.00	-877.95	0.00	-790.16

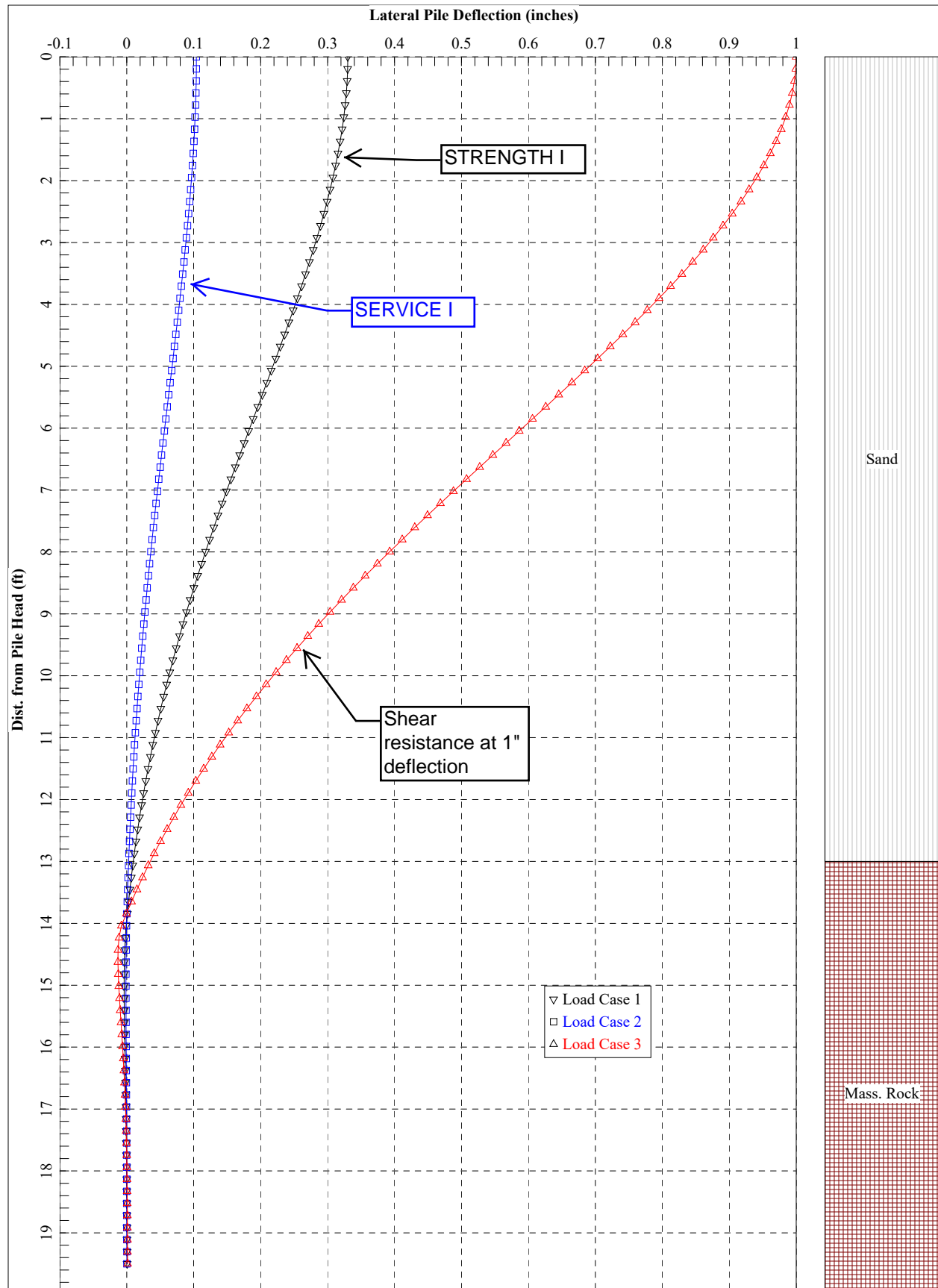
LAMSON ENGINEERING CORPORATION			Final Page No:	
Project:	Bridge No. W-38-003, Wilmington	Job No:	Preliminary Sheet No:	
Subject:	Wingwall Micropile Foundation	Prepared by:	SL	Date: 5/2023
Detail:	Lpile Analysis	Checked by:	JG	Date: 5/2023

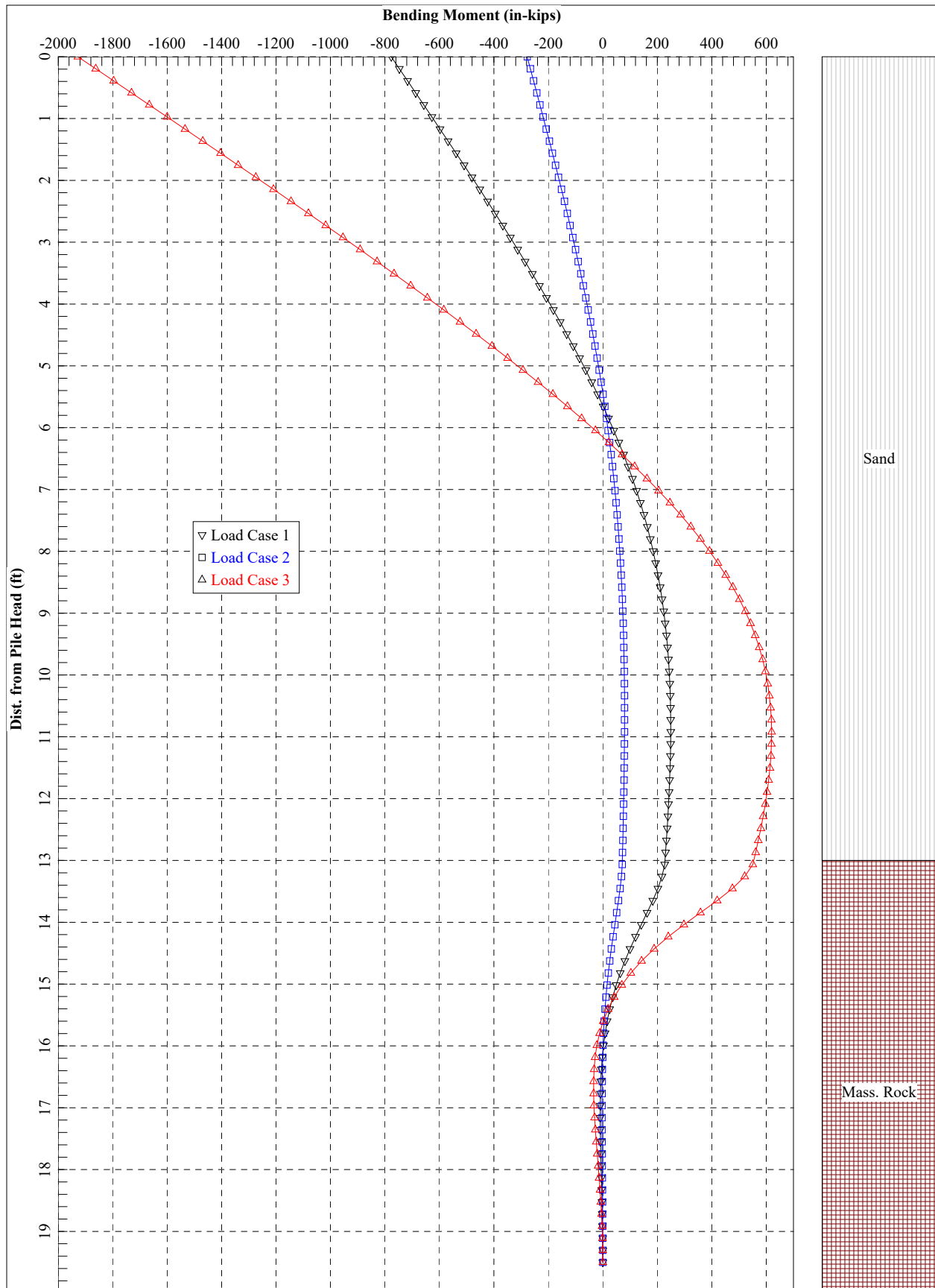


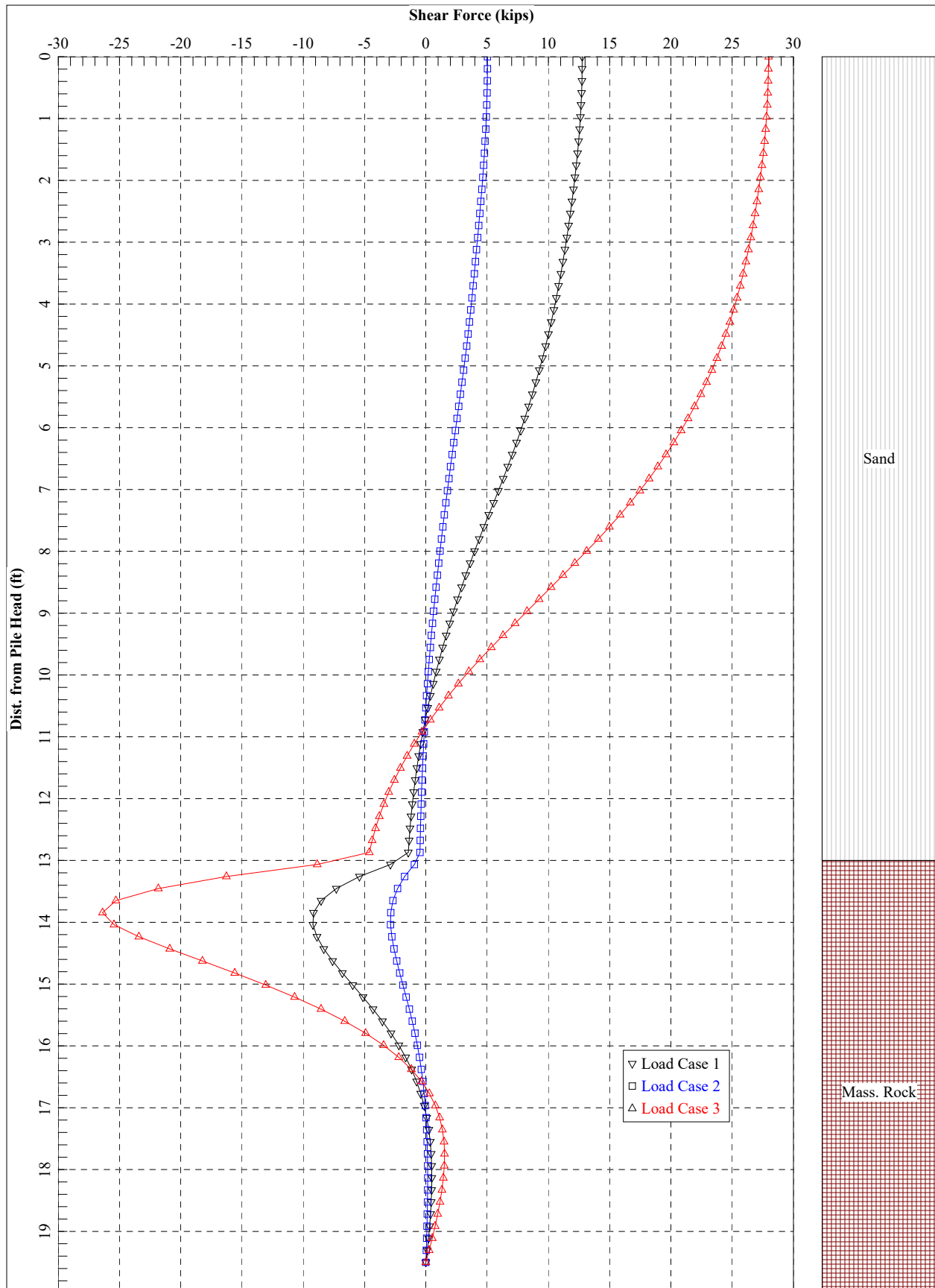
LAMSON ENGINEERING CORPORATION		Final Page No:	
Project:	Bridge No. W-38-003, Wilmington	Job No:	Preliminary Sheet No:
Subject:	Retaining Wall 1 Micropile Foundation	Prepared by: SL	Date: 12/2022
Detail:	Lpile Analysis	Checked by: JG	Date: 12/2022

Based on BB-3 at NW Retaining Wall









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LPILE for Windows, Version 2022-12.007

Analysis of Individual Piles and Drilled Shafts
Subjected to Lateral Loading Using the p-y Method
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Files Used for Analysis

Path to file locations:
\\Users\Lamson Engineering\Desktop\Charlie's Lamson Files\Green\W-38-003 (2NV) - Wilmington\6.1 Geotech Report -
Retaining Wall\LPILE\

Name of input data file:
Wilmington W38003_Retaining Wall Type 1 Micropile.lp12d

Name of output report file:
Wilmington W38003_Retaining Wall Type 1 Micropile.lp12o

Name of plot output file:
Wilmington W38003_Retaining Wall Type 1 Micropile.lp12p

Name of runtime message file:
Wilmington W38003_Retaining Wall Type 1 Micropile.lp12r

Date and Time of Analysis

Date: December 23, 2022 Time: 16:52:59

Problem Title

Butters Row Bridge W-38-003, Wilmington

Job Number:

Client: MassDOT

Engineer: Lamson Engineering Corporation

Description: Retaining Wall Type 1 Micropile

Program Options and Settings

Computational Options:

- Conventional Analysis

Engineering Units Used for Data Input and Computations:

- US Customary System Units (pounds, feet, inches)

Analysis Control Options:

- Maximum number of iterations allowed = 500
- Deflection tolerance for convergence = 1.0000E-05 in
- Maximum allowable deflection = 100.0000 in
- Number of pile increments = 100

Loading Type and Number of Cycles of Loading:

- Static loading specified
- Analysis uses p-y modification factors for p-y curves
- Analysis uses layering correction (Method of Georgiadis)
- No distributed lateral loads are entered
- Loading by lateral soil movements acting on pile not selected
- Input of shear resistance at the pile tip not selected
- Input of moment resistance at the pile tip not selected
- Computation of pile-head foundation stiffness matrix not selected
- Push-over analysis of pile not selected
- Buckling analysis of pile not selected

Output Options:

- Output files use decimal points to denote decimal symbols.
- Values of pile-head deflection, bending moment, shear force, and soil reaction are printed for full length of pile.
- Printing Increment (nodal spacing of output points) = 1
- No p-y curves to be computed and reported for user-specified depths
- Print using wide report formats

Pile Structural Properties and Geometry

Number of pile sections defined = 2
Total length of pile = 19.500 ft
Depth of ground surface below top of pile = 0.0000 ft

Pile diameters used for p-y curve computations are defined using 4 points.

p-y curves are computed using pile diameter values interpolated with depth over the length of the pile. A summary of values of pile diameter vs. depth follows.

Point No.	Depth Below Pile Head feet	Pile Diameter inches
1	0.000	10.7500
2	14.000	10.7500
3	14.000	9.5600

4 19.500 9.5600

Input Structural Properties for Pile Sections:

Pile Section No. 1:

Section 1 is a drilled shaft with permanent casing
 Length of section = 14.000000 ft
 Casing outside diameter = 10.750000 in

Pile Section No. 2:

Section 2 is a round drilled shaft, bored pile, or CIDH pile
 Length of section = 5.500000 ft
 Shaft Diameter = 9.560000 in

Ground Slope and Pile Batter Angles

Ground Slope Angle = 0.000 degrees
 = 0.000 radians

 Pile Batter Angle = 0.000 degrees
 = 0.000 radians

Soil and Rock Layering Information

The soil profile is modelled using 2 layers

Layer 1 is sand, p-y criteria by Reese et al., 1974

Distance from top of pile to top of layer = 0.0000 ft
 Distance from top of pile to bottom of layer = 13.000000 ft
 Effective unit weight at top of layer = 57.600000 pcf
 Effective unit weight at bottom of layer = 57.600000 pcf
 Friction angle at top of layer = 30.000000 deg.
 Friction angle at bottom of layer = 30.000000 deg.
 Subgrade k at top of layer = 20.000000 pci
 Subgrade k at bottom of layer = 20.000000 pci

Layer 2 is massive rock, p-y criteria by Liang et al., 2009

Distance from top of pile to top of layer = 13.000000 ft
 Distance from top of pile to bottom of layer = 20.500000 ft
 Effective unit weight at top of layer = 164.000000 pcf
 Effective unit weight at bottom of layer = 164.000000 pcf
 Uniaxial compressive strength at top of layer = 23836. psi
 Uniaxial compressive strength at bottom of layer = 23836. psi
 Poisson's ratio at top of layer = 0.090000
 Poisson's ratio at bottom of layer = 0.090000
 Option 1: Intact rock modulus at top of layer = 2480000. psi
 Intact rock modulus at bottom of layer = 2480000. psi
 Option 1: Geologic Strength Index for layer = 35.000000
 Option 2: Rock mass modulus at top of layer = 0.0000 psi
 Rock mass modulus at bottom of layer = 0.0000 psi
 Option 1 will be used to compute values of rock mass modulus for the p-y curve
 in massive rock.
 The rock type is (igneous) diorite, Hoek-Brown Material Constant $m_i = 25$

(Depth of the lowest soil layer extends 1.000 ft below the pile tip)

**** Warning - Possible Input Data Error ****

Values entered for effective unit weight of rock were outside the limits of 50 pcf to 150 pcf.

The maximum input value, in layer 1, for effective unit weight = 164.00 pcf

This data may be erroneous. Please check your data.

Summary of Input Soil Properties

Layer Geologic Num. Strength Index	Soil Type Int. Rock Name Modulus (p-y Curve Type) psi	Layer Hoek-Brown Depth Material ft Index, mi	Effective Unit Wt. Poisson's pcf Ratio	Angle of Friction deg.	Uniaxial qu psi	kpy pci	Rock Mass Modulus psi
1	Sand 0.00 (Reese, et al.) 0.00	0.00 0.00 13.0000 0.00	57.6000 0.00 57.6000 0.00	30.0000 30.0000	-- --	20.0000 20.0000	-- --
2	Massive 2480000. Rock 2480000.	13.0000 25.0000 20.5000 25.0000	164.0000 0.09000 164.0000 0.09000	-- --	23836. 23836.	-- --	Internally Computed

Modification Factors for p-y Curves

Distribution of p-y modifiers with depth defined using 2 points

Point No.	Depth X ft	p-mult	y-mult
1	0.000	0.7000	1.0000
2	13.000	0.7000	1.0000

Static Loading Type

Static loading criteria were used when computing p-y curves for all analyses.

Pile-head Loading and Pile-head Fixity Conditions

Number of loads specified = 3

Load No.	Load Type	Condition 1	Condition 2	Axial Thrust Force, lbs	Compute Top y vs. Pile Length	Run Analysis
-------------	--------------	----------------	----------------	----------------------------	----------------------------------	--------------

1	2	V =	12760. lbs	S =	0.0000 in/in	97670.	Yes	Yes
2	2	V =	5030. lbs	S =	0.0000 in/in	70520.	Yes	Yes
3	5	y =	1.000000 in	S =	0.0000 in/in	70520.	N.A.	Yes

V = shear force applied normal to pile axis

M = bending moment applied to pile head

y = lateral deflection normal to pile axis

S = pile slope relative to original pile batter angle

R = rotational stiffness applied to pile head

Values of top y vs. pile lengths can be computed only for load types with specified shear loading (Load Types 1, 2, and 3).

Thrust force is assumed to be acting axially for all pile batter angles.

Computations of Nominal Moment Capacity and Nonlinear Bending Stiffness

Axial thrust force values were determined from pile-head loading conditions

Number of Pile Sections Analyzed = 2

Pile Section No. 1:

Dimensions and Properties of Drilled Shaft (Bored Pile) with Permanent Casing:

Length of Section	=	14.000000 ft
Outer Diameter of Casing	=	10.750000 in
Concrete Cover Thickness Inside Casing	=	3.655000 in
Casing Wall Thickness	=	0.595000 in
Moment of Inertia of Steel Casing	=	245.530255 in^4
Yield Stress of Casing	=	52000. psi
Elastic Modulus of Casing	=	29000000. psi
Number of Reinforcing Bars	=	1 bar
Area of Single Reinforcing Bar	=	2.250000 sq. in.
Edge-to-Edge Bar Spacing	=	-1.69300 in
Maximum Concrete Aggregate Size	=	0.375000 in
Ratio of Bar Spacing to Aggregate Size	=	-4.51
Offset of Center of Rebar Cage from Center of Pile	=	0.0000 in
Yield Stress of Reinforcing Bars	=	60000. psi
Modulus of Elasticity of Reinforcing Bars	=	29000000. psi
Gross Area of Pile	=	90.762575 sq. in.
Area of Concrete	=	69.530366 sq. in.
Cross-sectional Area of Steel Casing	=	18.982210 sq. in.
Area of All Steel (Casing and Bars)	=	21.232210 sq. in.
Area Ratio of All Steel to Gross Area of Pile	=	23.39 percent

Axial Structural Capacities:

Nom. Axial Structural Capacity = $0.85 F_c A_c + F_y A_s$	=	1417.579 kips
Tensile Load for Cracking of Concrete	=	-103.016 kips
Nominal Axial Tensile Capacity	=	-1122.075 kips

Reinforcing Bar Dimensions and Positions Used in Computations:

Bar Number	Bar Diam. inches	Bar Area sq. in.	X inches	Y inches
-----	-----	-----	-----	-----
1	1.693000	2.250000	0.00000	0.00000

NOTE: The positions of the above rebars were computed by LPile

Concrete Properties:

Compressive Strength of Concrete	=	5000. psi
Modulus of Elasticity of Concrete	=	4030509. psi
Modulus of Rupture of Concrete	=	-530.33009 psi
Compression Strain at Peak Stress	=	0.002109
Tensile Strain at Fracture of Concrete	=	-0.0001150
Maximum Coarse Aggregate Size	=	0.375000 in

Number of Axial Thrust Force Values Determined from Pile-head Loadings = 2

Number	Axial Thrust Force kips
-----	-----
1	70.520
2	97.670

Definitions of Run Messages and Notes:

C = concrete in section has cracked in tension.
Y = stress in reinforcing steel has reached yield stress.
T = ACI 318 criteria for tension-controlled section met, tensile strain in reinforcement exceeds 0.005 while simultaneously compressive strain in concrete more than 0.003. See ACI 318-14, Section 21.2.3.
Z = depth of tensile zone in concrete section is less than 10 percent of section depth.

Bending Stiffness (EI) = Computed Bending Moment / Curvature.
Position of neutral axis is measured from edge of compression side of pile.
Compressive stresses and strains are positive in sign.
Tensile stresses and strains are negative in sign.

Axial Thrust Force = 70.520 kips

Bending Max Casing Run Curvature Stress Msg rad/in. ksi	Bending Moment in-kip	Bending Stiffness kip-in2	Depth to N Axis in	Max Comp Strain in/in	Max Tens Strain in/in	Max Conc Stress ksi	Max Steel Stress ksi
-----	-----	-----	-----	-----	-----	-----	-----
0.00000125	11.2580895	9006472.	65.4204455	0.00008178	0.00006834	0.3799371	2.2058740
2.3695427							
0.00000250	22.5152960	9006118.	35.3986414	0.00008850	0.00006162	0.4102160	2.2351671
2.5625046							
0.00000375	33.7724919	9005998.	25.3917844	0.00009522	0.00005491	0.4404023	2.2645050
2.7555113							
0.00000500	45.0296719	9005934.	20.3886642	0.0001019	0.00004819	0.4704960	2.2938876
2.9485626							
0.00000625	56.2868306	9005893.	17.3870387	0.0001087	0.00004148	0.5004970	2.3233149
3.1416586							
0.00000750	67.5439628	9005862.	15.3861606	0.0001154	0.00003477	0.5304053	2.3527868
3.3347993							
0.00000875	78.8010631	9005836.	13.9571382	0.0001221	0.00002806	0.5602206	2.3823033
3.5279846							
0.00001000	90.0581262	9005813.	12.8855255	0.0001289	0.00002136	0.5899431	2.4118648
3.7212148							
0.00001125	101.3151467	9005791.	12.0521859	0.0001356	0.00001465	0.6195726	2.4414709
3.9144896							
0.00001250	112.5721193	9005770.	11.3856376	0.0001423	0.00000795	0.6491090	2.4711217
4.1078092							
0.00001375	123.8290388	9005748.	10.8403921	0.0001491	0.00000124	0.6785523	2.5008172
4.3011735							

0.00001500	135.0858997	9005727.	10.3861235	0.0001558	-0.00000546	0.7079024	2.5305574
4.4945824							
0.00001625	146.3426921	9005704.	10.0018372	0.0001625	-0.00001216	0.7371593	2.5603423
4.6880361							
0.00001750	157.5991885	9005668.	9.6725341	0.0001693	-0.00001886	0.7663226	2.5901704
4.8815329							
0.00001875	168.8547535	9005587.	9.3872093	0.0001760	-0.00002555	0.7953916	2.6200372
5.0750685							
0.00002000	180.1087214	9005436.	9.1376083	0.0001828	-0.00003225	0.8243655	2.6499378
5.2686378							
0.00002125	191.3605269	9005201.	8.9174196	0.0001895	-0.00003894	0.8532436	2.6798677
5.4622364							
0.00002250	202.6097098	9004876.	8.7217353	0.0001962	-0.00004564	0.8820253	2.7098229
5.6558604							
0.00002375	213.8559000	9004459.	8.5466813	0.0002030	-0.00005233	0.9107099	2.7398002
5.8495065							
0.00002500	225.0988042	9003952.	8.3891593	0.0002097	-0.00005902	0.9392972	2.7697968
6.0431718							
0.00002625	236.3381853	9003359.	8.2466615	0.0002165	-0.00006571	0.9677867	2.7998102
6.2368540							
0.00002750	247.5738562	9002686.	8.1171368	0.0002232	-0.00007240	0.9961781	2.8298386
6.4305511							
0.00002875	258.8056620	9001936.	7.9988910	0.0002300	-0.00007909	1.0244711	2.8598802
6.6242614							
0.00003000	270.0334776	9001116.	7.8905126	0.0002367	-0.00008578	1.0526654	2.8899335
6.8179835							
0.00003125	281.2572009	9000230.	7.7908160	0.0002435	-0.00009247	1.0807610	2.9199974
7.0117161							
0.00003250	292.4767477	8999285.	7.6987984	0.0002502	-0.00009916	1.1087576	2.9500707
7.2054582							
0.00003375	303.6920502	8998283.	7.6136057	0.0002570	-0.000106	1.1366549	2.9801517
7.3992080							
0.00003500	314.9030486	8997230.	7.5345059	0.0002637	-0.000113	1.1644533	3.0102423
7.5929673							
0.00003625	314.9030486	8686981.	7.3597507	0.0002668	-0.000123	1.1769690	2.9340396
7.6804334 C							
0.00003750	323.9553912	8638810.	7.2843011	0.0002732	-0.000130	1.2030590	2.9531619
7.8632244 C							
0.00003875	334.0021413	8619410.	7.2135145	0.0002795	-0.000137	1.2290270	2.9720542
8.0457855 C							
0.00004000	344.0364028	8600910.	7.1470234	0.0002859	-0.000144	1.2548848	2.9907972
8.2281972 C							
0.00004125	354.0455001	8582921.	7.0842530	0.0002922	-0.000151	1.2806014	3.0091706
8.4102393 C							
0.00004250	364.0468139	8565807.	7.0251057	0.0002986	-0.000158	1.3062175	3.0274585
8.5921960 C							
0.00004375	374.0304930	8549268.	6.9691339	0.0003049	-0.000165	1.3317088	3.0454873
8.7738935 C							
0.00004500	384.0057439	8533461.	6.9161919	0.0003112	-0.000173	1.3570972	3.0634119
8.9554869 C							
0.00004625	393.9659730	8518183.	6.8659422	0.0003175	-0.000180	1.3823659	3.0811092
9.1368530 C							
0.00004750	403.9214673	8503610.	6.8183088	0.0003239	-0.000187	1.4075413	3.0987674
9.3181799 C							
0.00004875	413.8601664	8489439.	6.7729214	0.0003302	-0.000194	1.4325903	3.1161475
9.4992288 C							
0.00005125	433.7206030	8462841.	6.6886618	0.0003428	-0.000208	1.4823995	3.1507191
9.8611379 C							
0.00005375	453.5537433	8438209.	6.6120152	0.0003554	-0.000222	1.5318108	3.1849397
10.2226960 C							
0.00005625	473.3514515	8415137.	6.5418345	0.0003680	-0.000237	1.5807960	3.2185943
10.5836881 C							
0.00005875	493.1315598	8393729.	6.4775198	0.0003806	-0.000251	1.6294084	3.2520667
10.9444979 C							
0.00006125	512.8901115	8373716.	6.4182979	0.0003931	-0.000265	1.6776355	3.2852596
11.3050283 C							
0.00006375	532.6285209	8354957.	6.3635737	0.0004057	-0.000280	1.7254791	3.3181804
11.6652867 C							
0.00006625	552.3515213	8337381.	6.3129022	0.0004182	-0.000294	1.7729561	3.3509527

12.0253964 C							
0.00006875	572.0584045	8320850.	6.2658211	0.0004308	-0.000308	1.8200618	3.3835358
12.3853170 C							
0.00007125	591.7489634	8305249.	6.2219495	0.0004433	-0.000323	1.8667957	3.4159217
12.7450405 C							
0.00007375	611.4329421	8290616.	6.1810901	0.0004559	-0.000337	1.9131945	3.4483928
13.1048491 C							
0.00007625	631.0948135	8276653.	6.1427281	0.0004684	-0.000351	1.9591954	3.4804578
13.4642515 C							
0.00007875	650.7501538	8263494.	6.1068379	0.0004809	-0.000366	2.0048617	3.5126072
13.8237384 C							
0.00008125	670.3987370	8251061.	6.0731883	0.0004934	-0.000380	2.0501921	3.5448331
14.1833018 C							
0.00008375	690.0287070	8239149.	6.0414103	0.0005060	-0.000394	2.0951349	3.5767231
14.5425294 C							
0.00008625	709.6521381	8227851.	6.0115075	0.0005185	-0.000409	2.1397431	3.6086967
14.9018404 C							
0.00008875	729.2690123	8217116.	5.9833214	0.0005310	-0.000423	2.1840162	3.6407527
15.2612340 C							
0.00009125	748.8757991	8206858.	5.9566595	0.0005435	-0.000437	2.2279375	3.6727551
15.6205739 C							
0.00009375	768.4699017	8197012.	5.9313626	0.0005561	-0.000452	2.2714949	3.7046029
15.9797591 C							
0.00009625	788.0574479	8187610.	5.9074095	0.0005686	-0.000466	2.3147173	3.7365332
16.3390270 C							
0.00009875	807.6384304	8178617.	5.8846981	0.0005811	-0.000480	2.3576043	3.7685462
16.6983774 C							
0.0001013	827.2128413	8170003.	5.8631364	0.0005936	-0.000495	2.4001560	3.8006419
17.0578107 C							
0.0001038	846.7747870	8161685.	5.8425553	0.0006062	-0.000509	2.4423416	3.8325617
17.4170680 C							
0.0001063	866.3286031	8153681.	5.8229473	0.0006187	-0.000523	2.4841838	3.8644956
17.7763394 C							
0.0001088	885.8758474	8145985.	5.8042672	0.0006312	-0.000538	2.5256905	3.8965124
18.1356937 C							
0.0001113	905.4165125	8138575.	5.7864523	0.0006437	-0.000552	2.5668613	3.9286122
18.4951310 C							
0.0001138	924.9505906	8131434.	5.7694457	0.0006563	-0.000567	2.6076962	3.9607951
18.8546514 C							
0.0001163	944.4780741	8124543.	5.7531953	0.0006688	-0.000581	2.6481949	3.9930613
19.2142550 C							
0.0001188	963.9940739	8117845.	5.7375811	0.0006813	-0.000595	2.6883294	4.0251622
19.5736934 C							
0.0001213	983.5028005	8111363.	5.7226245	0.0006939	-0.000610	2.7281239	4.0573116
19.9331804 C							
0.0001238	1003.	8105090.	5.7082956	0.0007064	-0.000624	2.7675820	4.0895446
20.2927508 C							
0.0001263	1023.	8099014.	5.6945570	0.0007189	-0.000638	2.8067034	4.1218611
20.6524049 C							
0.0001288	1042.	8093121.	5.6813743	0.0007315	-0.000653	2.8454881	4.1542614
21.0121426 C							
0.0001313	1061.	8087403.	5.6687159	0.0007440	-0.000667	2.8839357	4.1867455
21.3719642 C							
0.0001338	1081.	8081849.	5.6565523	0.0007566	-0.000681	2.9220460	4.2193135
21.7318697 C							
0.0001363	1100.	8076450.	5.6448563	0.0007691	-0.000696	2.9598187	4.2519655
22.0918593 C							
0.0001388	1120.	8071173.	5.6335489	0.0007817	-0.000710	2.9972313	4.2844851
22.4517163 C							
0.0001413	1139.	8066032.	5.6226567	0.0007942	-0.000724	3.0343039	4.3170658
22.8116345 C							
0.0001438	1159.	8061024.	5.6121636	0.0008067	-0.000739	3.0710387	4.3497309
23.1716371 C							
0.0001463	1178.	8056141.	5.6020492	0.0008193	-0.000753	3.1074356	4.3824805
23.5317243 C							
0.0001488	1198.	8051378.	5.5922943	0.0008319	-0.000767	3.1434943	4.4153148
23.8918961 C							
0.0001588	1275.	8033407.	5.5565317	0.0008821	-0.000824	3.2843419	4.5475007
25.3334319 C							

0.0001688	1353.	8016908.	5.5252278	0.0009324	-0.000882	3.4197329	4.6807638
26.7760450 C							
0.0001788	1430.	8001617.	5.4975956	0.0009827	-0.000939	3.5496372	4.8149037
28.2195350 C							
0.0001888	1508.	7987376.	5.4731435	0.0010331	-0.000996	3.6740869	4.9504243
29.6644055 C							
0.0001988	1585.	7974022.	5.4513928	0.0010835	-0.001053	3.7930668	5.0873329
31.1106641 C							
0.0002088	1662.	7961426.	5.4319565	0.0011339	-0.001110	3.9065612	5.2256371
32.5583183 C							
0.0002188	1739.	7949460.	5.4144417	0.0011844	-0.001167	4.0145192	5.3648575
34.0068887 C							
0.0002288	1816.	7938056.	5.3986559	0.0012349	-0.001224	4.1169572	5.5053888
35.4567700 C							
0.0002388	1893.	7927145.	5.3843980	0.0012855	-0.001281	4.2138674	5.6473433
36.9080746 C							
0.0002488	1969.	7916667.	5.3714848	0.0013362	-0.001338	4.3052335	-5.841444
-38.411525 C							
0.0002588	2046.	7906567.	5.3597616	0.0013868	-0.001395	4.3910395	-6.164243
-40.043674 C							
0.0002688	2122.	7896804.	5.3490965	0.0014376	-0.001451	4.4712689	-6.485596
-41.674377 C							
0.0002788	2199.	7887337.	5.3393767	0.0014884	-0.001508	4.5459052	-6.805493
-43.303624 C							
0.0002888	2275.	7878134.	5.3305049	0.0015392	-0.001565	4.6149318	-7.123926
-44.931407 C							
0.0002988	2351.	7869168.	5.3223970	0.0015901	-0.001621	4.6783320	-7.440887
-46.557718 C							
0.0003088	2427.	7860407.	5.3149451	0.0016410	-0.001678	4.7360771	-7.756677
-48.182858 C							
0.0003188	2503.	7851835.	5.3081166	0.0016920	-0.001735	4.7881626	-8.071026
-49.806557 C							
0.0003288	2579.	7843434.	5.3018614	0.0017430	-0.001791	4.8345734	-8.383870
-51.428751 C							
0.0003388	2653.	7832513.	5.2954677	0.0017938	-0.001848	4.8751242	-8.701702
-52.000000 CY							
0.0003488	2723.	7808314.	5.2872382	0.0018439	-0.001905	4.9094934	-9.041811
52.000000 CY							
0.0003588	2786.	7766608.	5.2782234	0.0018936	-0.001963	4.9381075	-9.394862
52.000000 CY							
0.0003688	2841.	7703538.	5.2679876	0.0019426	-0.002021	4.9610375	-9.766199
52.000000 CY							
0.0003788	2888.	7623960.	5.2573979	0.0019912	-0.002080	4.9785800	-10.147359
52.000000 CY							
0.0003888	2929.	7533241.	5.2476848	0.0020400	-0.002139	4.9909397	-10.524780
52.000000 CY							
0.0003988	2965.	7435034.	5.2388484	0.0020890	-0.002198	4.9980771	-10.897695
52.000000 CY							
0.0004088	2997.	7332403.	5.2304669	0.0021380	-0.002256	4.9984715	-11.270344
52.000000 CY							
0.0004188	3026.	7227325.	5.2224455	0.0021869	-0.002315	4.9986576	-11.643481
52.000000 CY							
0.0004288	3053.	7121269.	5.2147928	0.0022358	-0.002373	4.9986704	-12.016686
52.000000 CY							
0.0004388	3078.	7014910.	5.2075153	0.0022848	-0.002432	4.9985135	-12.389555
52.000000 CY							
0.0004488	3100.	6908683.	5.2006409	0.0023338	-0.002490	4.9981605	-12.761401
52.000000 CY							
0.0004588	3121.	6803368.	5.1939395	0.0023827	-0.002549	4.9988607	-13.134932
52.000000 CY							
0.0004688	3140.	6699484.	5.1874428	0.0024316	-0.002607	4.9999737	-13.509567
52.000000 CY							
0.0004788	3158.	6597012.	5.1813459	0.0024806	-0.002666	4.9997689	-13.882418
52.000000 CY							
0.0004888	3175.	6496141.	5.1757011	0.0025296	-0.002724	4.9992467	-14.252398
52.000000 CY							
0.0004988	3191.	6397371.	5.1701943	0.0025786	-0.002783	4.9982345	-14.623659
52.000000 CY							
0.0005088	3205.	6299968.	5.1648766	0.0026276	-0.002841	4.9999992	-14.995318

52.0000000 CY 0.0005188	3219.	6204704.	5.1599295	0.0026767	-0.002900	4.9996462	-15.364490
52.0000000 CY 0.0005288	3232.	6111806.	5.1552407	0.0027258	-0.002958	4.9984818	-15.732572
52.0000000 CY 0.0005388	3243.	6020229.	5.1507080	0.0027749	-0.003017	5.0000000	-16.100929
52.0000000 CY 0.0005488	3255.	5931245.	5.1463263	0.0028240	-0.003075	4.9994434	-16.469520
52.0000000 CY 0.0006088	3310.	5437112.	5.1250436	0.0031199	-0.003424	4.9999872	-18.646012
52.0000000 CY 0.0006688	3350.	5008834.	5.1098493	0.0034172	-0.003772	4.9994716	-20.778475
52.0000000 CY 0.0007288	3379.	4636639.	5.0989967	0.0037159	-0.004118	4.9995582	-22.872068
52.0000000 CY 0.0007888	3401.	4311915.	5.0921040	0.0040164	-0.004463	4.9999999	-24.912852
52.0000000 CY							

Axial Thrust Force = 97.670 kips

Bending Max Casing Run Curvature Stress rad/in. ksi	Bending Moment in-kip	Bending Stiffness kip-in2	Depth to N Axis in	Max Comp Strain in/in	Max Tens Strain in/in	Max Conc Stress ksi	Max Steel Stress ksi
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0.00000125 3.2148659	11.2248686	8979895.	88.7397060	0.0001109	0.00009749	0.5118451	3.0511972
0.00000250 3.4078282	22.4485116	8979405.	47.0582761	0.0001176	0.00009077	0.5416879	3.0804907
0.00000375 3.6008353	33.6721440	8979238.	33.1648792	0.0001244	0.00008406	0.5714382	3.1098291
0.00000500 3.7938874	44.8957604	8979152.	26.2184906	0.0001311	0.00007734	0.6010957	3.1392124
0.00000625 3.9869844	56.1193555	8979097.	22.0509053	0.0001378	0.00007063	0.6306604	3.1686407
0.00000750 4.1801263	67.3429238	8979057.	19.2727216	0.0001445	0.00006392	0.6601323	3.1981138
0.00000875 4.3733132	78.5664601	8979024.	17.2884817	0.0001513	0.00005721	0.6895113	3.2276320
0.00001000 4.5665450	89.7899590	8978996.	15.8004568	0.0001580	0.00005050	0.7187973	3.2571950
0.00001125 4.7598217	101.0134152	8978970.	14.6432417	0.0001647	0.00004380	0.7479903	3.2868029
0.00001250 4.9531433	112.2368232	8978946.	13.7175935	0.0001715	0.00003709	0.7770901	3.3164558
0.00001375 5.1465099	123.4601778	8978922.	12.9603577	0.0001782	0.00003039	0.8060968	3.3461536
0.00001500 5.3399214	134.6834736	8978898.	12.3294312	0.0001849	0.00002369	0.8350102	3.3758964
0.00001625 5.5333778	145.9067052	8978874.	11.7956656	0.0001917	0.00001699	0.8638302	3.4056840
0.00001750 5.7268787	157.1298676	8978850.	11.3382407	0.0001984	0.00001029	0.8925568	3.4355162
0.00001875 5.9204250	168.3529548	8978824.	10.9418885	0.0002052	0.00000360	0.9211900	3.4653937
0.00002000 6.1140162	179.5759619	8978798.	10.5951577	0.0002119	-0.00000310	0.9497296	3.4953162
0.00002125 6.3076523	190.7988833	8978771.	10.2892917	0.0002186	-0.00000979	0.9781757	3.5252836
0.00002250 6.5013336	202.0217074	8978743.	10.0174796	0.0002254	-0.00001648	1.0065281	3.5552961
0.00002375 6.6950583	213.2442539	8978705.	9.7743428	0.0002321	-0.00002317	1.0347865	3.5853521
0.00002500 6.888236	224.4660705	8978643.	9.5555756	0.0002389	-0.00002986	1.0629505	3.6154486

0.00002625	235.6866578	8978539.	9.3576920	0.0002456	-0.00003655	1.0910194	3.6455821
7.0826259							
0.00002750	246.9055526	8978384.	9.1778397	0.0002524	-0.00004323	1.1189928	3.6757491
7.2764616							
0.00002875	258.1223454	8978169.	9.0136629	0.0002591	-0.00004992	1.1468700	3.7059462
7.4703275							
0.00003000	269.3366890	8977890.	8.8631988	0.0002659	-0.00005660	1.1746506	3.7361706
7.6642206							
0.00003125	280.5482803	8977545.	8.7247991	0.0002726	-0.00006329	1.2023343	3.7664196
7.8581383							
0.00003250	291.7568636	8977134.	8.5970691	0.0002794	-0.00006997	1.2299205	3.7966908
8.0520783							
0.00003375	302.9622234	8976658.	8.4788213	0.0002862	-0.00007665	1.2574091	3.8269824
8.2460386							
0.00003500	314.1641753	8976119.	8.3690379	0.0002929	-0.00008333	1.2847997	3.8572923
8.4400173							
0.00003625	325.3625616	8975519.	8.2668418	0.0002997	-0.00009001	1.3120920	3.8876191
8.6340128							
0.00003750	336.5572480	8974860.	8.1714729	0.0003064	-0.00009669	1.3392859	3.9179612
8.8280237							
0.00003875	347.7481187	8974145.	8.0822694	0.0003132	-0.000103	1.3663811	3.9483175
9.0220488							
0.00004000	358.9350728	8973377.	7.9986523	0.0003199	-0.000110	1.3933775	3.9786868
9.2160868							
0.00004125	360.9987488	8751485.	7.8569824	0.0003241	-0.000119	1.4098190	3.9335481
9.3346169 C							
0.00004250	371.1922747	8733936.	7.7776969	0.0003306	-0.000126	1.4354260	3.9550272
9.5197647 C							
0.00004375	381.3552952	8716692.	7.7026720	0.0003370	-0.000133	1.4608942	3.9761637
9.7045699 C							
0.00004500	391.4901592	8699781.	7.6315643	0.0003434	-0.000140	1.4862262	3.9969728
9.8890478 C							
0.00004625	401.6085366	8683428.	7.5641686	0.0003498	-0.000147	1.5114431	4.0176054
10.0733491 C							
0.00004750	411.7001469	8667372.	7.5000847	0.0003563	-0.000154	1.5365251	4.0379136
10.2573261 C							
0.00004875	421.7741059	8651777.	7.4391398	0.0003627	-0.000161	1.5614883	4.0580137
10.4410950 C							
0.00005125	441.8695733	8621845.	7.3257437	0.0003754	-0.000175	1.6110589	4.0975820
10.8080008 C							
0.00005375	461.9042955	8593568.	7.2224190	0.0003882	-0.000190	1.6601702	4.1364068
11.1741630 C							
0.00005625	481.8871324	8566882.	7.1278861	0.0004009	-0.000204	1.7088381	4.1745909
11.5396846 C							
0.00005875	501.8263671	8541725.	7.0410865	0.0004137	-0.000218	1.7570788	4.2122435
11.9046748 C							
0.00006125	521.7153053	8517801.	6.9609860	0.0004264	-0.000232	1.8048735	4.2492093
12.2689781 C							
0.00006375	541.5721278	8495249.	6.8869567	0.0004390	-0.000246	1.8522628	4.2857848
12.6328910 C							
0.00006625	561.4037262	8474019.	6.8183760	0.0004517	-0.000260	1.8992638	4.3220942
12.9965379 C							
0.00006875	581.1969632	8453774.	6.7545084	0.0004644	-0.000275	1.9458412	4.3578560
13.3596373 C							
0.00007125	600.9704495	8434673.	6.6950299	0.0004770	-0.000289	1.9920418	4.3934261
13.7225448 C							
0.00007375	620.7181299	8416517.	6.6394331	0.0004897	-0.000303	2.0378498	4.4286737
14.0851300 C							
0.00007625	640.4458115	8399289.	6.5873832	0.0005023	-0.000317	2.0832790	4.4637030
14.4474967 C							
0.00007875	660.1515187	8382876.	6.5385222	0.0005149	-0.000332	2.1283243	4.4984676
14.8095988 C							
0.00008125	679.8443297	8367315.	6.4926396	0.0005275	-0.000346	2.1730108	4.5331650
15.1716338 C							
0.00008375	699.5115056	8352376.	6.4493386	0.0005401	-0.000360	2.2173003	4.5674799
15.5332861 C							
0.00008625	719.1720017	8338226.	6.4085821	0.0005527	-0.000374	2.2612504	4.6018804
15.8950241 C							
0.00008875	738.8108150	8324629.	6.3699991	0.0005653	-0.000389	2.3048128	4.6359651

16.2564464 C							
0.00009125	758.4360663	8311628.	6.3334927	0.0005779	-0.000403	2.3480141	4.6699506
16.6177694 C							
0.00009375	778.0546348	8299249.	6.2989646	0.0005905	-0.000417	2.3908765	4.7040212
16.9791774 C							
0.00009625	797.6535028	8287309.	6.2661246	0.0006031	-0.000432	2.4333551	4.7377972
17.3402909 C							
0.00009875	817.2399398	8275847.	6.2349183	0.0006157	-0.000446	2.4754754	4.7714898
17.7013211 C							
0.0001013	836.8196942	8264886.	6.2052819	0.0006283	-0.000460	2.5172570	4.8052672
18.0624359 C							
0.0001038	856.3904920	8254366.	6.1770778	0.0006409	-0.000474	2.5586913	4.8390566
18.4235629 C							
0.0001063	875.9417781	8244158.	6.1500951	0.0006534	-0.000489	2.5997397	4.8725175
18.7843613 C							
0.0001088	895.4864084	8234358.	6.1243798	0.0006660	-0.000503	2.6404499	4.9060656
19.1452469 C							
0.0001113	915.0243491	8224938.	6.0998464	0.0006786	-0.000517	2.6808214	4.9396982
19.5062169 C							
0.0001138	934.5555924	8215873.	6.0764171	0.0006912	-0.000532	2.7208538	4.9734154
19.8672716 C							
0.0001163	954.0697384	8207052.	6.0539108	0.0007038	-0.000546	2.7605064	5.0068469
20.2280407 C							
0.0001188	973.5758206	8198533.	6.0323624	0.0007163	-0.000560	2.7998149	5.0403139
20.5888452 C							
0.0001213	993.0752064	8190311.	6.0117266	0.0007289	-0.000575	2.8387844	5.0738655
20.9497342 C							
0.0001238	1013.	8182367.	5.9919482	0.0007415	-0.000589	2.8774148	5.1075016
21.3107079 C							
0.0001263	1032.	8174684.	5.9729762	0.0007541	-0.000603	2.9157057	5.1412225
21.6717662 C							
0.0001288	1052.	8167202.	5.9547011	0.0007667	-0.000617	2.9536325	5.1747942
22.0326755 C							
0.0001313	1071.	8159928.	5.9371091	0.0007792	-0.000632	2.9912059	5.2083164
22.3935351 C							
0.0001338	1090.	8152877.	5.9201967	0.0007918	-0.000646	3.0284399	5.2419233
22.7544795 C							
0.0001363	1110.	8146034.	5.9039263	0.0008044	-0.000660	3.0653342	5.2756151
23.1155089 C							
0.0001388	1129.	8139390.	5.8882635	0.0008170	-0.000675	3.1018886	5.3093920
23.4766233 C							
0.0001413	1149.	8132933.	5.8731758	0.0008296	-0.000689	3.1381028	5.3432540
23.8378227 C							
0.0001438	1168.	8126654.	5.8586327	0.0008422	-0.000703	3.1739767	5.3772012
24.1991075 C							
0.0001463	1188.	8120495.	5.8445319	0.0008548	-0.000717	3.2094782	5.4109099
24.5601536 C							
0.0001488	1207.	8114498.	5.8309248	0.0008674	-0.000732	3.2446398	5.4447064
24.9212877 C							
0.0001588	1285.	8091974.	5.7809679	0.0009177	-0.000789	3.3818789	5.5807482
26.3666795 C							
0.0001688	1362.	8071437.	5.7371371	0.0009681	-0.000846	3.5136221	5.7177946
27.8130758 C							
0.0001788	1439.	8052513.	5.6983354	0.0010186	-0.000903	3.6398273	5.8554887
29.2601199 C							
0.0001888	1517.	8035016.	5.6638988	0.0010691	-0.000960	3.7605474	5.9945711
30.7085524 C							
0.0001988	1594.	8018702.	5.6331127	0.0011196	-0.001017	3.8757412	6.1347210
32.1580522 C							
0.0002088	1671.	8003382.	5.6054105	0.0011701	-0.001074	3.9853777	6.2756838
33.6083650 C							
0.0002188	1748.	7988957.	5.5804637	0.0012207	-0.001131	4.0894892	6.4180592
35.0600904 C							
0.0002288	1824.	7975309.	5.5579121	0.0012714	-0.001188	4.1880599	6.5618549
36.5132362 C							
0.0002388	1901.	7962337.	5.5374560	0.0013221	-0.001244	4.2810735	6.7070788
37.9678100 C							
0.0002488	1978.	7949925.	5.5187490	0.0013728	-0.001301	4.3684743	6.8530564
39.4231376 C							

0.0002588	2054.	7938037.	5.5016749	0.0014236	-0.001358	4.4502887	7.0004363
40.8798675 C							
0.0002688	2130.	7926613.	5.4860582	0.0014744	-0.001415	4.5265029	7.1492719
42.3380532 C							
0.0002788	2206.	7915602.	5.4717431	0.0015252	-0.001471	4.5971003	7.2995716
43.7977028 C							
0.0002888	2283.	7904959.	5.4585954	0.0015762	-0.001528	4.6620642	7.4513436
45.2588248 C							
0.0002988	2359.	7894645.	5.4464987	0.0016271	-0.001584	4.7213775	7.6045963
46.7214276 C							
0.0003088	2434.	7884627.	5.4353520	0.0016782	-0.001641	4.7750232	7.7593383
48.1855196 C							
0.0003188	2510.	7874869.	5.4250464	0.0017292	-0.001697	4.8229784	7.9153904
49.6509216 C							
0.0003288	2586.	7865343.	5.4154922	0.0017803	-0.001754	4.8652242	8.0726293
51.1175106 C							
0.0003388	2661.	7854681.	5.4070257	0.0018316	-0.001810	4.9018375	8.2350122
52.0000000 CY							
0.0003488	2732.	7832449.	5.3993248	0.0018830	-0.001866	4.9327136	8.4002268
52.0000000 CY							
0.0003588	2795.	7792077.	5.3923149	0.0019345	-0.001922	4.9578175	8.5681641
52.0000000 CY							
0.0003688	2851.	7731426.	5.3852948	0.0019858	-0.001978	4.9770404	8.7319265
52.0000000 CY							
0.0003788	2898.	7652174.	5.3778905	0.0020369	-0.002035	4.9904023	8.8873962
52.0000000 CY							
0.0003888	2939.	7560405.	5.3704095	0.0020877	-0.002091	4.9980108	-9.141218
52.0000000 CY							
0.0003988	2975.	7461648.	5.3629914	0.0021385	-0.002148	4.9986447	-9.462136
52.0000000 CY							
0.0004088	3008.	7358678.	5.3556800	0.0021891	-0.002205	4.9990129	-9.786099
52.0000000 CY							
0.0004188	3037.	7253288.	5.3484935	0.0022397	-0.002262	4.9991933	-10.112785
52.0000000 CY							
0.0004288	3064.	7146744.	5.3414391	0.0022901	-0.002319	4.9992294	-10.441997
52.0000000 CY							
0.0004388	3089.	7039981.	5.3345180	0.0023405	-0.002376	4.9991308	-10.773605
52.0000000 CY							
0.0004488	3111.	6933428.	5.3278803	0.0023909	-0.002433	4.9988779	-11.105539
52.0000000 CY							
0.0004588	3132.	6827593.	5.3215630	0.0024413	-0.002490	4.9984178	-11.437060
52.0000000 CY							
0.0004688	3151.	6723151.	5.3153640	0.0024916	-0.002547	4.9979012	-11.770637
52.0000000 CY							
0.0004788	3170.	6620423.	5.3093262	0.0025418	-0.002605	4.9999769	-12.105571
52.0000000 CY							
0.0004888	3186.	6519075.	5.3038443	0.0025923	-0.002662	4.9997195	-12.436128
52.0000000 CY							
0.0004988	3202.	6419316.	5.2982987	0.0026425	-0.002719	4.9990314	-12.770786
52.0000000 CY							
0.0005088	3216.	6321713.	5.2928998	0.0026928	-0.002776	4.9977139	-13.106495
52.0000000 CY							
0.0005188	3230.	6225901.	5.2881142	0.0027432	-0.002833	4.9999448	-13.436110
52.0000000 CY							
0.0005288	3242.	6132246.	5.2832139	0.0027935	-0.002891	4.9992445	-13.770261
52.0000000 CY							
0.0005388	3254.	6040300.	5.2786863	0.0028439	-0.002948	4.9975289	-14.101428
52.0000000 CY							
0.0005488	3266.	5950840.	5.2744057	0.0028943	-0.003005	4.9998650	-14.431293
52.0000000 CY							
0.0006088	3320.	5453974.	5.2520756	0.0031972	-0.003347	4.9963570	-16.403412
52.0000000 CY							
0.0006688	3359.	5022993.	5.2358092	0.0035014	-0.003688	4.9999020	-18.335641
52.0000000 CY							
0.0007288	3388.	4648854.	5.2239650	0.0038070	-0.004027	4.9953063	-20.231027
52.0000000 CY							

Summary of Results for Nominal Moment Capacity for Section 1

Moment values interpolated at maximum compressive strain = 0.003
or maximum developed moment if pile fails at smaller strains.

Load No.	Axial Thrust kips	Nominal Mom. Cap. in-kip	Max. Comp. Strain	Max. Tens. Strain
1	70.520	3287.527	0.00300000	-0.00328270
2	97.670	3284.567	0.00300000	-0.00312410

Note that the values of moment capacity in the table above are not factored by a strength reduction factor (phi-factor).

In ACI 318, the value of the strength reduction factor depends on whether the transverse reinforcing steel bars are tied hoops (0.65) or spirals (0.75).

The above values should be multiplied by the appropriate strength reduction factor to compute ultimate moment capacity according to ACI 318, or the value required by the design standard being followed.

The following table presents factored moment capacities and corresponding bending stiffnesses computed for common resistance factor values used for reinforced concrete sections.

Axial Load No.	Resist. Factor	Nominal Ax. Thrust kips	Nominal Moment Cap in-kips	Ult. (Fac) Ax. Thrust kips	Ult. (Fac) Moment Cap in-kips	Bend. Stiff. at Ult Mom kip-in^2
1	0.65	70.520000	3288.	45.838000	2137.	7894990.
2	0.65	97.670000	3285.	63.485500	2135.	7925935.
1	0.75	70.520000	3288.	52.890000	2466.	7856029.
2	0.75	97.670000	3285.	73.252500	2463.	7880884.
1	0.90	70.520000	3288.	63.468000	2959.	7451176.
2	0.90	97.670000	3285.	87.903000	2956.	7514051.

Pile Section No. 2:

Dimensions and Properties of Drilled Shaft (Bored Pile):

Length of Section	=	5.500000 ft
Shaft Diameter	=	9.560000 in
Concrete Cover Thickness (to edge of long. rebar)	=	3.655000 in
Number of Reinforcing Bars	=	1 bar
Yield Stress of Reinforcing Bars	=	60000. psi
Modulus of Elasticity of Reinforcing Bars	=	29000000. psi
Gross Area of Shaft	=	71.780366 sq. in.
Total Area of Reinforcing Steel	=	2.250000 sq. in.
Area Ratio of Steel Reinforcement	=	3.13 percent
Edge-to-Edge Bar Spacing	=	-1.69300 in
Maximum Concrete Aggregate Size	=	0.375000 in
Ratio of Bar Spacing to Aggregate Size	=	-4.51
Offset of Center of Rebar Cage from Center of Pile	=	0.0000 in

Axial Structural Capacities:

Nom. Axial Structural Capacity = $0.85 F_c A_c + F_y A_s$	=	430.504 kips
Tensile Load for Cracking of Concrete	=	-39.723 kips
Nominal Axial Tensile Capacity	=	-135.000 kips

Reinforcing Bar Dimensions and Positions Used in Computations:

Bar Number	Bar Diam. inches	Bar Area sq. in.	X inches	Y inches
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1	1.693000	2.250000	0.00000	0.00000

NOTE: The positions of the above rebars were computed by LPILE

Concrete Properties:

Compressive Strength of Concrete	=	5000. psi
Modulus of Elasticity of Concrete	=	4030509. psi
Modulus of Rupture of Concrete	=	-530.33009 psi
Compression Strain at Peak Stress	=	0.002109
Tensile Strain at Fracture of Concrete	=	-0.0001150
Maximum Coarse Aggregate Size	=	0.375000 in

Number of Axial Thrust Force Values Determined from Pile-head Loadings = 2

Number	Axial Thrust Force kips
-----	-----
1	70.520
2	97.670

Definitions of Run Messages and Notes:

- C = concrete in section has cracked in tension.
- Y = stress in reinforcing steel has reached yield stress.
- T = ACI 318 criteria for tension-controlled section met, tensile strain in reinforcement exceeds 0.005 while simultaneously compressive strain in concrete more than 0.003. See ACI 318-14, Section 21.2.3.
- Z = depth of tensile zone in concrete section is less than 10 percent of section depth.

Bending Stiffness (EI) = Computed Bending Moment / Curvature.
 Position of neutral axis is measured from edge of compression side of pile.
 Compressive stresses and strains are positive in sign.
 Tensile stresses and strains are negative in sign.

Axial Thrust Force = 70.520 kips

Bending Curvature rad/in.	Bending Moment in-kip	Bending Stiffness kip-in2	Depth to N Axis in	Max Comp Strain in/in	Max Tens Strain in/in	Max Conc Stress ksi	Max Steel Stress ksi	Run Msg
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0.00000125	2.2315886	1785271.	153.0657512	0.0001913	0.0001794	0.8658410	5.4048152	
0.00000250	4.4609798	1784392.	78.9252190	0.0001973	0.0001734	0.8913317	5.4344419	
0.00000375	6.6903440	1784092.	54.2127569	0.0002033	0.0001674	0.9167604	5.4641826	
0.00000500	8.9196675	1783934.	41.8573124	0.0002093	0.0001615	0.9421270	5.4940373	
0.00000625	11.1489369	1783830.	34.4446750	0.0002153	0.0001555	0.9674313	5.5240061	
0.00000750	13.3781385	1783752.	29.5034411	0.0002213	0.0001496	0.9926731	5.5540890	
0.00000875	15.6072587	1783687.	25.9744377	0.0002273	0.0001436	1.0178524	5.5842859	
0.00001000	17.8362839	1783628.	23.3280786	0.0002333	0.0001377	1.0429688	5.6145968	
0.00001125	20.0652007	1783573.	21.2701488	0.0002393	0.0001317	1.0680224	5.6450218	
0.00001250	22.2939953	1783520.	19.6241197	0.0002453	0.0001258	1.0930128	5.6755609	
0.00001375	24.5226541	1783466.	18.2776547	0.0002513	0.0001199	1.1179401	5.7062141	
0.00001500	26.7511637	1783411.	17.1558628	0.0002573	0.0001139	1.1428039	5.7369813	
0.00001625	28.9795104	1783354.	16.2068963	0.0002634	0.0001080	1.1676042	5.7678627	
0.00001750	31.2076806	1783296.	15.3937213	0.0002694	0.0001021	1.1923408	5.7988581	
0.00001875	33.4356607	1783235.	14.6891795	0.0002754	0.00009617	1.2170135	5.8299676	
0.00002000	35.6634371	1783172.	14.0729021	0.0002815	0.00009026	1.2416222	5.8611913	

0.00002125	37.8909963	1783106.	13.5293132	0.0002875	0.00008435	1.2661668	5.8925290
0.00002250	40.1183246	1783037.	13.0462979	0.0002935	0.00007844	1.2906470	5.9239809
0.00002375	42.3454084	1782965.	12.6142920	0.0002996	0.00007254	1.3150627	5.9555470
0.00002500	44.5722341	1782889.	12.2256442	0.0003056	0.00006664	1.3394137	5.9872271
0.00002625	46.7987881	1782811.	11.8741605	0.0003117	0.00006075	1.3637000	6.0190215
0.00002750	49.0250568	1782729.	11.5547729	0.0003178	0.00005486	1.3879212	6.0509300
0.00002875	51.2510267	1782644.	11.2632952	0.0003238	0.00004897	1.4120774	6.0829527
0.00003000	53.4766840	1782556.	10.9962385	0.0003299	0.00004309	1.4361683	6.1150896
0.00003125	55.7020152	1782464.	10.7506724	0.0003360	0.00003721	1.4601937	6.1473407
0.00003250	57.9270066	1782369.	10.5241172	0.0003420	0.00003133	1.4841535	6.1797060
0.00003375	60.1516447	1782271.	10.3144605	0.0003481	0.00002546	1.5080476	6.2121856
0.00003500	62.3759158	1782169.	10.1198919	0.0003542	0.00001960	1.5318758	6.2447794
0.00003625	64.5998062	1782064.	9.9388506	0.0003603	0.00001373	1.5556379	6.2774875
0.00003750	66.8233024	1781955.	9.7699837	0.0003664	0.00000787	1.5793338	6.3103099
0.00003875	69.0463907	1781842.	9.6121132	0.0003725	0.00000202	1.6029633	6.3432466
0.00004000	71.2690529	1781726.	9.4642081	0.0003786	-0.00000383	1.6265262	6.3762975
0.00004125	73.4911821	1781604.	9.3253611	0.0003847	-0.00000968	1.6500222	6.4094611
0.00004250	75.7125546	1781472.	9.1947700	0.0003908	-0.00001552	1.6734507	6.4427337
0.00004375	77.9329025	1781323.	9.0717235	0.0003969	-0.00002136	1.6968108	6.4761106
0.00004500	80.1519583	1781155.	8.9555892	0.0004030	-0.00002720	1.7201017	6.5095870
0.00004625	82.3694601	1780961.	8.8458031	0.0004091	-0.00003303	1.7433228	6.5431583
0.00004750	84.5851576	1780740.	8.7418606	0.0004152	-0.00003886	1.7664732	6.5768197
0.00004875	86.7988176	1780489.	8.6433090	0.0004214	-0.00004469	1.7895523	6.6105666
0.00005125	91.2191829	1779886.	8.4607894	0.0004336	-0.00005633	1.8354936	6.6783001
0.00005375	95.6290439	1779145.	8.2954370	0.0004459	-0.00006797	1.8811417	6.7463265
0.00005625	100.0271343	1778260.	8.1449462	0.0004582	-0.00007960	1.9264925	6.8146215
0.00005875	104.4123882	1777232.	8.0074055	0.0004704	-0.00009121	1.9715421	6.8831590
0.00006125	108.7839435	1776064.	7.8812179	0.0004827	-0.000103	2.0162872	6.9519188
0.00006375	113.1410585	1774762.	7.7650377	0.0004950	-0.000114	2.0607248	7.0208828
0.00006625	113.1410585	1707790.	7.5409596	0.0004996	-0.000134	2.0768735	6.8657016 C
0.00006875	113.1410585	1645688.	7.4245125	0.0005104	-0.000147	2.1156365	6.8926182 C
0.00007125	113.1410585	1587945.	7.3148946	0.0005212	-0.000160	2.1537986	6.9167610 C
0.00007375	114.0334745	1546217.	7.2113706	0.0005318	-0.000173	2.1913559	6.9380423 C
0.00007625	116.2343600	1524385.	7.1135050	0.0005424	-0.000187	2.2283595	6.9568249 C
0.00007875	118.3544901	1502914.	7.0208305	0.0005529	-0.000200	2.2648353	6.9732712 C
0.00008125	120.3989094	1481833.	6.9329022	0.0005633	-0.000213	2.3007987	6.9874638 C
0.00008375	122.3668780	1461097.	6.8492435	0.0005736	-0.000227	2.3362401	6.9992765 C
0.00008625	124.2700284	1440812.	6.7696159	0.0005839	-0.000241	2.3712045	7.0090417 C
0.00008875	126.1149897	1421014.	6.6937483	0.0005941	-0.000254	2.4057179	7.0169382 C
0.00009125	127.9082705	1401734.	6.6214057	0.0006042	-0.000268	2.4398075	7.0231622 C
0.00009375	129.6526345	1382961.	6.5523298	0.0006143	-0.000282	2.4734847	7.0277778 C
0.00009625	131.3329268	1364498.	6.4860090	0.0006243	-0.000296	2.5066703	7.0300672 C
0.00009875	132.9767449	1346600.	6.4226192	0.0006342	-0.000310	2.5394964	7.0311342 C
0.0001013	134.5854833	1329239.	6.3619602	0.0006441	-0.000324	2.5719712	7.0310276 C
0.0001038	136.1365316	1312159.	6.3034697	0.0006540	-0.000338	2.6039732	7.0286497 C
0.0001063	137.6655107	1295675.	6.2475119	0.0006638	-0.000352	2.6356868	7.0255949 C
0.0001088	139.1495003	1279536.	6.1935607	0.0006735	-0.000366	2.6669896	7.0207545 C
0.0001113	140.6050086	1263865.	6.1417069	0.0006833	-0.000380	2.6979667	7.0148578 C
0.0001138	142.0292832	1248609.	6.0917688	0.0006929	-0.000395	2.7286046	7.0077619 C
0.0001163	143.4218841	1233737.	6.0435958	0.0007026	-0.000409	2.7588960	6.9993753 C
0.0001188	144.7892003	1219277.	5.9971714	0.0007122	-0.000423	2.7888792	6.9900254 C
0.0001213	146.1290765	1205188.	5.9523373	0.0007217	-0.000437	2.8185376	6.9795362 C
0.0001238	147.4421869	1191452.	5.9090058	0.0007312	-0.000452	2.8478767	6.9679382 C
0.0001263	148.7390998	1178131.	5.8672355	0.0007407	-0.000466	2.8769567	6.9557730 C
0.0001288	150.0007384	1165054.	5.8266398	0.0007502	-0.000481	2.9056621	6.9419369 C
0.0001313	151.2596188	1152454.	5.7876428	0.0007596	-0.000495	2.9341931	6.9282995 C
0.0001338	152.4768539	1140014.	5.7495470	0.0007690	-0.000510	2.9623029	6.9125030 C
0.0001363	153.6870168	1127978.	5.7128314	0.0007784	-0.000524	2.9902130	6.8966363 C
0.0001388	154.8819794	1116267.	5.6772891	0.0007877	-0.000539	3.0178685	6.8801665 C
0.0001413	156.0461072	1104751.	5.6426124	0.0007970	-0.000553	3.0451680	6.8620891 C
0.0001438	157.2075546	1093618.	5.6091872	0.0008063	-0.000568	3.0722975	6.8442008 C
0.0001463	158.3485259	1082725.	5.5766661	0.0008156	-0.000583	3.0991353	6.8253004 C
0.0001488	159.4683317	1072056.	5.5449914	0.0008248	-0.000597	3.1256784	6.8053353 C
0.0001588	163.8439516	1032088.	5.4274687	0.0008616	-0.000656	3.2296263	6.7217917 C
0.0001688	168.0399141	995792.	5.3223710	0.0008982	-0.000715	3.3299137	6.6308898 C
0.0001788	172.0815348	962694.	5.2278404	0.0009345	-0.000774	3.4267104	6.5338084 C
0.0001888	175.9909062	932402.	5.1424099	0.0009706	-0.000834	3.5201715	6.4317111 C
0.0001988	179.7875197	904591.	5.0649132	0.0010067	-0.000893	3.6104411	6.3257879 C
0.0002088	183.4887471	878988.	4.9944173	0.0010426	-0.000953	3.6976566	6.2173053 C

0.0002188	187.1026185	855326.	4.9300513	0.0010784	-0.001013	3.7818840	6.1068195	C
0.0002288	190.6188338	833306.	4.8707778	0.0011142	-0.001073	3.8630191	5.9927833	C
0.0002388	194.0759595	812884.	4.8165480	0.0011500	-0.001132	3.9413991	5.8792892	C
0.0002488	197.4487718	793764.	4.7663224	0.0011856	-0.001192	4.0167938	-5.960559	C
0.0002588	200.7685242	775917.	4.7201199	0.0012213	-0.001252	4.0894774	-6.546872	C
0.0002688	204.0127320	759117.	4.6771074	0.0012570	-0.001312	4.1592405	-7.135120	C
0.0002788	207.2166165	743378.	4.6375274	0.0012927	-0.001372	4.2264037	-7.720567	C
0.0002888	210.3402885	728451.	4.6003184	0.0013283	-0.001432	4.2905802	-8.309118	C
0.0002988	213.4225112	714385.	4.5659115	0.0013641	-0.001492	4.3521369	-8.894973	C
0.0003088	216.4562560	701073.	4.5339120	0.0013998	-0.001552	4.4109902	-9.479229	C
0.0003188	219.4231297	688386.	4.5037572	0.0014356	-0.001612	4.4669609	-10.064994	C
0.0003288	222.3488549	676346.	4.4757449	0.0014714	-0.001671	4.5202866	-10.647823	C
0.0003388	225.2328928	664894.	4.4496893	0.0015073	-0.001731	4.5709451	-11.227676	C
0.0003488	228.0531716	653916.	4.4249955	0.0015432	-0.001791	4.6187175	-11.808859	C
0.0003588	230.8269047	643420.	4.4018849	0.0015792	-0.001850	4.6637618	-12.387901	C
0.0003688	233.5581323	633378.	4.3803170	0.0016152	-0.001910	4.7060982	-12.963850	C
0.0003788	236.2462761	623753.	4.3601736	0.0016514	-0.001969	4.7457026	-13.536663	C
0.0003888	238.8819433	614487.	4.3411571	0.0016876	-0.002029	4.7824770	-14.108453	C
0.0003988	241.4634851	605551.	4.3231526	0.0017239	-0.002088	4.8164018	-14.679571	C
0.0004088	244.0009565	596944.	4.3063062	0.0017602	-0.002147	4.8475461	-15.247404	C
0.0004188	246.4937309	588642.	4.2905392	0.0017967	-0.002207	4.8758838	-15.811899	C
0.0004288	248.9411653	580621.	4.2757802	0.0018332	-0.002266	4.9013881	-16.373007	C
0.0004388	251.3426000	572861.	4.2619644	0.0018699	-0.002325	4.9240317	-16.930674	C
0.0004488	253.6922959	565331.	4.2489076	0.0019067	-0.002383	4.9437580	-17.486488	C
0.0004588	255.9879925	558012.	4.2365105	0.0019435	-0.002442	4.9605422	-18.041083	C
0.0004688	258.2363593	550904.	4.2249104	0.0019804	-0.002501	4.9744024	-18.592034	C
0.0004788	260.4366622	543993.	4.2140620	0.0020175	-0.002559	4.9853082	-19.139278	C
0.0004888	262.5881466	537265.	4.2039236	0.0020547	-0.002618	4.9932285	-19.682751	C
0.0004988	264.6900367	530707.	4.1944572	0.0020920	-0.002676	4.9981314	-20.222387	C
0.0005088	266.7415333	524308.	4.1856278	0.0021294	-0.002734	4.9998388	-20.758118	C
0.0005188	268.7357265	518045.	4.1774249	0.0021670	-0.002792	4.9997026	-21.289541	C
0.0005288	270.6716265	511909.	4.1698191	0.0022048	-0.002850	4.9989546	-21.816572	C
0.0005388	272.5500423	505893.	4.1627768	0.0022427	-0.002908	4.9977737	-22.339199	C
0.0005488	274.3645899	499981.	4.1562235	0.0022807	-0.002965	4.9988435	-22.858135	C
0.0006088	284.0422592	466599.	4.1263222	0.0025119	-0.003308	4.9987391	-25.885300	C
0.0006688	291.8654498	436434.	4.1100890	0.0027486	-0.003645	4.9988785	-28.751445	C
0.0007288	298.1155036	409078.	4.1036338	0.0029905	-0.003976	4.9960977	-31.467437	C
0.0007888	303.0287063	384189.	4.1042707	0.0032372	-0.004303	4.9981614	-34.043671	C
0.0008488	306.8158780	361491.	4.1100483	0.0034884	-0.004626	4.9981587	-36.491155	C
0.0009088	309.6378540	340729.	4.1196098	0.0037437	-0.004944	4.9960452	-38.818815	C
0.0009688	309.6378540	319626.	4.1460141	0.0040165	-0.005245	4.9960173	-40.640020	C

Axial Thrust Force = 97.670 kips

Bending Curvature rad/in.	Bending Moment in-kip	Bending Stiffness kip-in2	Depth to N Axis in	Max Comp Strain in/in	Max Tens Strain in/in	Max Conc Stress ksi	Max Steel Stress ksi	Run Msg
0.00000125	2.1456731	1716539.	213.3864140	0.0002667	0.0002548	1.1845560	7.5914393	
0.00000250	4.2882493	1715300.	109.0856282	0.0002727	0.0002488	1.2090437	7.6210715	
0.00000375	6.4307976	1714879.	74.3197832	0.0002787	0.0002428	1.2334692	7.6508217	
0.00000500	8.5733039	1714661.	56.9376734	0.0002847	0.0002369	1.2578325	7.6806897	
0.00000625	10.7157543	1714521.	46.5090578	0.0002907	0.0002309	1.2821333	7.7106755	
0.00000750	12.8581346	1714418.	39.5571892	0.0002967	0.0002250	1.3063716	7.7407792	
0.00000875	15.0004308	1714335.	34.5920332	0.0003027	0.0002190	1.3305471	7.7710007	
0.00001000	17.1426289	1714263.	30.8685726	0.0003087	0.0002131	1.3546596	7.8013401	
0.00001125	19.2847148	1714197.	27.9729089	0.0003147	0.0002071	1.3787091	7.8317973	
0.00001250	21.4266746	1714134.	25.6567032	0.0003207	0.0002012	1.4026953	7.8623724	
0.00001375	23.5684941	1714072.	23.7619213	0.0003267	0.0001953	1.4266181	7.8930654	
0.00001500	25.7101593	1714011.	22.1832075	0.0003327	0.0001893	1.4504774	7.9238763	
0.00001625	27.8516563	1713948.	20.8476228	0.0003388	0.0001834	1.4742729	7.9548050	
0.00001750	29.9929708	1713884.	19.7030682	0.0003448	0.0001775	1.4980045	7.9858517	
0.00001875	32.1340890	1713818.	18.7113378	0.0003508	0.0001716	1.5216721	8.0170162	
0.00002000	34.2749967	1713750.	17.8437770	0.0003569	0.0001657	1.5452754	8.0482987	
0.00002125	36.4156799	1713679.	17.0784735	0.0003629	0.0001598	1.5688144	8.0796991	
0.00002250	38.5561245	1713606.	16.3983844	0.0003690	0.0001539	1.5922888	8.1112174	
0.00002375	40.6963165	1713529.	15.7900550	0.0003750	0.0001480	1.6156985	8.1428537	
0.00002500	42.8362418	1713450.	15.2427211	0.0003811	0.0001421	1.6390433	8.1746079	

0.00002625	44.9758864	1713367.	14.7476693	0.0003871	0.0001362	1.6623231	8.2064801
0.00002750	47.1152361	1713281.	14.2977701	0.0003932	0.0001303	1.6855377	8.2384702
0.00002875	49.2542771	1713192.	13.8871341	0.0003993	0.0001244	1.7086869	8.2705784
0.00003000	51.3929950	1713100.	13.5108534	0.0004053	0.0001185	1.7317706	8.3028046
0.00003125	53.5313760	1713004.	13.1648054	0.0004114	0.0001127	1.7547886	8.3351488
0.00003250	55.6694059	1712905.	12.8455018	0.0004175	0.0001068	1.7777408	8.3676110
0.00003375	57.8070707	1712802.	12.5499708	0.0004236	0.0001009	1.8006269	8.4001913
0.00003500	59.9443562	1712696.	12.2756656	0.0004296	0.00009505	1.8234469	8.4328897
0.00003625	62.0812484	1712586.	12.0203903	0.0004357	0.00008919	1.8462005	8.4657061
0.00003750	64.2177332	1712473.	11.7822419	0.0004418	0.00008333	1.8688877	8.4986407
0.00003875	66.3537965	1712356.	11.5595631	0.0004479	0.00007748	1.8915082	8.5316934
0.00004000	68.4894242	1712236.	11.3509035	0.0004540	0.00007164	1.9140618	8.5648642
0.00004125	70.6246022	1712112.	11.1549888	0.0004601	0.00006579	1.9365484	8.5981532
0.00004250	72.7593164	1711984.	10.9706944	0.0004663	0.00005995	1.9589679	8.6315604
0.00004375	74.8935528	1711853.	10.7970242	0.0004724	0.00005412	1.9813201	8.6650858
0.00004500	77.0272971	1711718.	10.6330930	0.0004785	0.00004829	2.0036048	8.6987294
0.00004625	79.1605353	1711579.	10.4781110	0.0004846	0.00004246	2.0258218	8.7324913
0.00004750	81.2932533	1711437.	10.3313719	0.0004907	0.00003664	2.0479710	8.7663715
0.00004875	83.4254368	1711291.	10.1922416	0.0004969	0.00003082	2.0700523	8.8003699
0.00005125	87.6881444	1710988.	9.9345803	0.0005091	0.00001920	2.1140102	8.8687219
0.00005375	91.9485449	1710671.	9.7011913	0.0005214	0.00000759	2.1576942	8.9375473
0.00005625	96.2065229	1710338.	9.4888383	0.0005337	-0.00000400	2.2011031	9.0068464
0.00005875	100.4616470	1709985.	9.2948327	0.0005461	-0.00001558	2.2442347	9.0766137
0.00006125	104.7127059	1709595.	9.1169165	0.0005584	-0.00002714	2.2870854	9.1468289
0.00006375	108.9582202	1709149.	8.9531827	0.0005708	-0.00003868	2.3296507	9.2174660
0.00006625	113.1967522	1708630.	8.8020118	0.0005831	-0.00005022	2.3719263	9.2884981
0.00006875	117.4269485	1708028.	8.6620202	0.0005955	-0.00006174	2.4139079	9.3598991
0.00007125	121.6476188	1707335.	8.5320195	0.0006079	-0.00007324	2.4555918	9.4316453
0.00007375	125.8576745	1706545.	8.4109833	0.0006203	-0.00008474	2.4969743	9.5037140
0.00007625	130.0561824	1705655.	8.2980206	0.0006327	-0.00009623	2.5380523	9.5760851
0.00007875	134.2423158	1704664.	8.1923547	0.0006451	-0.000108	2.5788227	9.6487405
0.00008125	134.2423158	1652213.	8.0324021	0.0006526	-0.000124	2.6030645	9.5781615 C
0.00008375	134.3911646	1604671.	7.9287603	0.0006640	-0.000137	2.6399597	9.6211542 C
0.00008625	137.1137129	1589724.	7.8301960	0.0006754	-0.000149	2.6763093	9.6618188 C
0.00008875	139.7397573	1574532.	7.7363084	0.0006866	-0.000162	2.7121273	9.7002282 C
0.00009125	142.2754295	1559183.	7.6467468	0.0006978	-0.000175	2.7474295	9.7364719 C
0.00009375	144.7270412	1543755.	7.5612046	0.0007089	-0.000187	2.7822329	9.7706565 C
0.00009625	147.1010274	1528322.	7.4794127	0.0007199	-0.000200	2.8165563	9.8029057 C
0.00009875	149.4038955	1512951.	7.4011355	0.0007309	-0.000213	2.8504196	9.8333603 C
0.0001013	151.6281568	1497562.	7.3260065	0.0007418	-0.000226	2.8837942	9.8617087 C
0.0001038	153.7816010	1482232.	7.2538551	0.0007526	-0.000239	2.9167034	9.8881220 C
0.0001063	155.8793079	1467099.	7.1846185	0.0007634	-0.000252	2.9491998	9.9130549 C
0.0001088	157.9278114	1452210.	7.1181588	0.0007741	-0.000266	2.9813075	9.9367058 C
0.0001113	159.9009377	1437312.	7.0539787	0.0007848	-0.000279	3.0129266	9.9580747 C
0.0001138	161.8290554	1422673.	6.9922414	0.0007954	-0.000292	3.0441683	9.9781927 C
0.0001163	163.7209182	1408352.	6.9328841	0.0008059	-0.000305	3.0750686	9.9973866 C
0.0001188	165.5400706	1394022.	6.8753312	0.0008164	-0.000319	3.1054821	10.0141871 C
0.0001213	167.3339945	1380074.	6.8199853	0.0008269	-0.000332	3.1355949	10.0304027 C
0.0001238	169.0747512	1366261.	6.7663961	0.0008373	-0.000346	3.1652958	10.0448953 C
0.0001263	170.7796327	1352710.	6.7146343	0.0008477	-0.000359	3.1946525	10.0583110 C
0.0001288	172.4470231	1339394.	6.6645739	0.0008581	-0.000373	3.2236600	10.0705730 C
0.0001313	174.0738971	1326277.	6.6160667	0.0008684	-0.000386	3.2523021	10.0814863 C
0.0001338	175.6706283	1313425.	6.5691407	0.0008786	-0.000400	3.2806254	10.0915016 C
0.0001363	177.2303533	1300773.	6.5236168	0.0008888	-0.000414	3.3085970	10.1002519 C
0.0001388	178.7591584	1288354.	6.4794866	0.0008990	-0.000427	3.3362454	10.1080081 C
0.0001413	180.2622795	1276193.	6.4367231	0.0009092	-0.000441	3.3635912	10.1149651 C
0.0001438	181.7259323	1264180.	6.3950960	0.0009193	-0.000455	3.3905745	10.1204574 C
0.0001463	183.1826692	1252531.	6.3549108	0.0009294	-0.000469	3.4173410	10.1260305 C
0.0001488	184.5839426	1240900.	6.3155325	0.0009394	-0.000483	3.4436689	10.1292565 C
0.0001588	190.0189546	1196970.	6.1694090	0.0009794	-0.000538	3.5463613	10.1374991 C
0.0001688	195.0807421	1156034.	6.0378152	0.0010189	-0.000594	3.6443875	10.1320948 C
0.0001788	199.8584550	1118089.	5.9190391	0.0010580	-0.000651	3.7381806	10.1168095 C
0.0001888	204.3840466	1082829.	5.8112218	0.0010969	-0.000708	3.8279069	10.0926199 C
0.0001988	208.6838572	1049982.	5.7128521	0.0011354	-0.000765	3.9137085	10.0603502 C
0.0002088	212.7831568	1019321.	5.6227274	0.0011737	-0.000822	3.9957258	10.0209387 C
0.0002188	216.7098768	990674.	5.5399312	0.0012119	-0.000879	4.0741175	9.9757455 C
0.0002288	220.4904573	963893.	5.4637313	0.0012498	-0.000937	4.1490364	9.9262883 C
0.0002388	224.1471860	938836.	5.3935106	0.0012877	-0.000995	4.2206144	9.8740337 C
0.0002488	227.6663001	915241.	5.3283221	0.0013254	-0.001053	4.2887754	9.8173522 C

0.0002588	231.0801487	893063.	5.2679105	0.0013631	-0.001111	4.3537026	9.7587068 C
0.0002688	234.4122320	872232.	5.2120269	0.0014007	-0.001169	4.4155366	9.7003113 C
0.0002788	237.6202603	852449.	5.1596113	0.0014382	-0.001227	4.4740301	9.6375392 C
0.0002888	240.7710638	833839.	5.1111261	0.0014758	-0.001285	4.5295660	9.5772775 C
0.0002988	243.8099456	816100.	5.0654603	0.0015133	-0.001343	4.5818293	9.5133153 C
0.0003088	246.7989507	799349.	5.0231293	0.0015509	-0.001401	4.6311662	9.4527346 C
0.0003188	249.6860446	783329.	4.9831205	0.0015884	-0.001459	4.6772789	9.3890657 C
0.0003288	252.5170927	768113.	4.9458276	0.0016259	-0.001517	4.7204173	9.3280844 C
0.0003388	255.2796994	753593.	4.9108376	0.0016635	-0.001575	4.7604975	9.2680961 C
0.0003488	257.9606651	739672.	4.8777695	0.0017011	-0.001633	4.7974503	9.2072510 C
0.0003588	260.5903821	726384.	4.8468847	0.0017388	-0.001691	4.8314147	9.1499398 C
0.0003688	263.1543822	713639.	4.8178032	0.0017766	-0.001749	4.8623016	9.0940004 C
0.0003788	265.6405705	701361.	4.7902076	0.0018143	-0.001807	4.8900525	9.0375141 C
0.0003888	268.0743368	689580.	4.7643575	0.0018521	-0.001864	4.9147622	-9.337398 C
0.0003988	270.4548620	678257.	4.7401263	0.0018901	-0.001922	4.9363999	-9.857791 C
0.0004088	272.7611049	667305.	4.7170738	0.0019281	-0.001980	4.9548740	-10.378267 C
0.0004188	275.0029102	656723.	4.6952735	0.0019661	-0.002037	4.9702092	-10.896907 C
0.0004288	277.1900932	646508.	4.6748043	0.0020043	-0.002095	4.9824096	-11.411642 C
0.0004388	279.3217653	636631.	4.6555802	0.0020426	-0.002152	4.9914415	-11.922405 C
0.0004488	281.3970120	627069.	4.6375233	0.0020811	-0.002209	4.9972702	-12.429129 C
0.0004588	283.3941261	617753.	4.6201891	0.0021195	-0.002266	4.9998556	-12.936710 C
0.0004688	285.3277913	608699.	4.6039016	0.0021581	-0.002323	4.9996336	-13.440104 C
0.0004788	287.1955005	599886.	4.5886305	0.0021968	-0.002380	4.9992088	-13.938860 C
0.0004888	288.9966206	591297.	4.5743193	0.0022357	-0.002437	4.9984815	-14.432855 C
0.0004988	290.7314261	582920.	4.5609117	0.0022748	-0.002493	4.9999988	-14.922081 C
0.0005088	292.3950576	574732.	4.5483756	0.0023140	-0.002550	4.9997861	-15.406225 C
0.0005188	293.9894864	566727.	4.5365304	0.0023533	-0.002606	4.9990965	-15.887246 C
0.0005288	295.5151914	558894.	4.5252626	0.0023927	-0.002662	4.9977489	-16.366284 C
0.0005388	296.9760449	551232.	4.5147324	0.0024323	-0.002718	4.9998544	-16.840334 C
0.0005488	298.3764095	543738.	4.5048866	0.0024721	-0.002774	4.9989670	-17.309599 C
0.0006088	305.6268169	502056.	4.4580147	0.0027138	-0.003106	4.9999573	-20.029694 C
0.0006688	311.1240232	465232.	4.4270098	0.0029606	-0.003433	4.9998528	-22.605163 C
0.0007288	315.1989804	432520.	4.4075680	0.0032120	-0.003755	4.9975765	-25.044168 C
0.0007888	318.1082968	403307.	4.3967398	0.0034679	-0.004073	4.9985455	-27.353804 C
0.0008488	320.0427796	377075.	4.3922431	0.0037279	-0.004386	4.9977859	-29.545282 C
0.0009088	320.0427796	352179.	4.4070525	0.0040049	-0.004683	4.9961227	-31.243619 C

Summary of Results for Nominal Moment Capacity for Section 2

Moment values interpolated at maximum compressive strain = 0.003
or maximum developed moment if pile fails at smaller strains.

Load No.	Axial Thrust kips	Nominal Mom. Cap. in-kip	Max. Comp. Strain	Max. Tens. Strain
1	70.520	298.304	0.00300000	-0.00398888
2	97.670	311.763	0.00300000	-0.00348321

Note that the values of moment capacity in the table above are not factored by a strength reduction factor (phi-factor).

In ACI 318, the value of the strength reduction factor depends on whether the transverse reinforcing steel bars are tied hoops (0.65) or spirals (0.75).

The above values should be multiplied by the appropriate strength reduction factor to compute ultimate moment capacity according to ACI 318, or the value required by the design standard being followed.

The following table presents factored moment capacities and corresponding bending stiffnesses computed for common resistance factor values used for reinforced concrete sections.

Axial Load No.	Resist. Factor	Nominal Ax. Thrust kips	Nominal Moment Cap in-kips	Ult. (Fac) Ax. Thrust kips	Ult. (Fac) Moment Cap in-kips	Bend. Stiff. at Ult Mom kip-in^2
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1	0.65	70.520000	298.304226	45.838000	193.897747	813936.
2	0.65	97.670000	311.763130	63.485500	202.646035	1096371.
1	0.75	70.520000	298.304226	52.890000	223.728169	670869.
2	0.75	97.670000	311.763130	73.252500	233.822348	875919.
1	0.90	70.520000	298.304226	63.468000	268.473803	518867.
2	0.90	97.670000	311.763130	87.903000	280.586817	630802.

Layering Correction Equivalent Depths of Soil & Rock Layers

Layer No.	Top of Layer Below Pile Head ft	Equivalent Top Depth Below Grnd Surf ft	Same Layer Type As Layer Above	Layer is Rock or is Below Rock Layer	F0 Integral for Layer lbs	F1 Integral for Layer lbs
1	0.00	0.00	N.A.	No	0.00	81556.
2	13.0000	13.0000	No	Yes	N.A.	N.A.

Notes: The F0 integral of Layer n+1 equals the sum of the F0 and F1 integrals for Layer n. Layering correction equivalent depths are computed only for soil types with both shallow-depth and deep-depth expressions for peak lateral load transfer. These soil types are soft and stiff clays, non-liquefied sands, and cemented c-phi soil.

Computed Values of Pile Loading and Deflection
for Lateral Loading for Load Case Number 1

Pile-head conditions are Shear and Pile-head Rotation (Loading Type 2)

Shear force at pile head = 12760.0 lbs
Rotation of pile head = 0.000E+00 radians
Axial load at pile head = 97670.0 lbs

(Zero slope for this load indicates fixed-head conditions)

Depth X feet	Deflect. y inches	Bending Moment in-lbs	Shear Force lbs	Slope S radians	Total Stress psi*	Bending Stiffness lb-in^2	Soil Res. p lb/inch	Soil Spr. Es*H lb/inch	Distrib. Lat. Load lb/inch
0.00	0.3302	-776853.	12760.	0.00	0.00	8.30E+09	0.00	0.00	0.00
0.1950	0.3299	-746970.	12755.	-2.15E-04	0.00	8.30E+09	-4.447	31.5412	0.00
0.3900	0.3292	-717063.	12738.	-4.21E-04	0.00	8.34E+09	-9.484	67.4138	0.00
0.5850	0.3280	-687162.	12710.	-6.17E-04	0.00	8.36E+09	-14.869	106.0863	0.00
0.7800	0.3263	-657298.	12669.	-8.05E-04	0.00	8.39E+09	-20.369	146.0685	0.00
0.9750	0.3242	-627504.	12615.	-9.84E-04	0.00	8.41E+09	-25.806	186.2589	0.00
1.1700	0.3217	-597811.	12548.	-0.00115	0.00	8.44E+09	-31.028	225.6951	0.00
1.3650	0.3188	-568250.	12470.	-0.00132	0.00	8.47E+09	-35.838	263.0486	0.00
1.5600	0.3155	-538850.	12381.	-0.00147	0.00	8.50E+09	-40.669	301.5895	0.00
1.7550	0.3119	-509638.	12280.	-0.00161	0.00	8.53E+09	-44.907	336.8772	0.00
1.9500	0.3080	-480640.	12171.	-0.00175	0.00	8.57E+09	-48.813	370.8594	0.00
2.1450	0.3038	-451880.	12053.	-0.00188	0.00	8.61E+09	-52.056	401.0246	0.00
2.3400	0.2992	-423376.	11927.	-0.00199	0.00	8.65E+09	-55.158	431.3538	0.00
2.5350	0.2944	-395149.	11795.	-0.00210	0.00	8.69E+09	-58.217	462.7013	0.00
2.7300	0.2894	-367216.	11655.	-0.00221	0.00	8.74E+09	-61.003	493.3043	0.00
2.9250	0.2841	-339594.	11508.	-0.00230	0.00	8.97E+09	-65.001	535.4015	0.00
3.1200	0.2786	-312308.	11351.	-0.00239	0.00	8.98E+09	-68.549	575.7441	0.00
3.3150	0.2729	-285379.	11188.	-0.00246	0.00	8.98E+09	-71.567	613.5893	0.00
3.5100	0.2671	-258825.	11017.	-0.00253	0.00	8.98E+09	-73.972	648.1048	0.00

3.7050	0.2611	-232660.	10839.	-0.00260	0.00	8.98E+09	-78.027	699.3623	0.00
3.9000	0.2549	-206909.	10651.	-0.00266	0.00	8.98E+09	-83.303	764.6674	0.00
4.0950	0.2486	-181601.	10450.	-0.00271	0.00	8.98E+09	-88.485	832.7429	0.00
4.2900	0.2423	-156768.	10237.	-0.00275	0.00	8.98E+09	-93.542	903.5436	0.00
4.4850	0.2358	-132437.	10012.	-0.00279	0.00	8.98E+09	-98.471	977.3054	0.00
4.6800	0.2292	-108637.	9775.	-0.00282	0.00	8.98E+09	-104.261	1064.	0.00
4.8750	0.2226	-85402.	9524.	-0.00284	0.00	8.98E+09	-110.020	1157.	0.00
5.0700	0.2159	-62764.	9260.	-0.00286	0.00	8.98E+09	-115.730	1254.	0.00
5.2650	0.2092	-40756.	8983.	-0.00288	0.00	8.98E+09	-121.377	1358.	0.00
5.4600	0.2024	-19410.	8692.	-0.00289	0.00	8.98E+09	-126.947	1467.	0.00
5.6550	0.1957	1241.	8389.	-0.00289	0.00	8.98E+09	-132.427	1584.	0.00
5.8500	0.1889	21168.	8072.	-0.00288	0.00	8.98E+09	-137.804	1707.	0.00
6.0450	0.1822	40339.	7744.	-0.00288	0.00	8.98E+09	-143.068	1838.	0.00
6.2400	0.1755	58724.	7403.	-0.00286	0.00	8.98E+09	-148.201	1977.	0.00
6.4350	0.1688	76294.	7050.	-0.00285	0.00	8.98E+09	-153.153	2123.	0.00
6.6300	0.1621	93021.	6686.	-0.00282	0.00	8.98E+09	-157.899	2279.	0.00
6.8250	0.1556	108877.	6312.	-0.00280	0.00	8.98E+09	-162.423	2443.	0.00
7.0200	0.1490	123838.	5927.	-0.00277	0.00	8.98E+09	-166.706	2617.	0.00
7.2150	0.1426	137879.	5532.	-0.00273	0.00	8.98E+09	-170.732	2801.	0.00
7.4100	0.1363	150976.	5134.	-0.00270	0.00	8.98E+09	-169.620	2913.	0.00
7.6050	0.1300	163136.	4741.	-0.00265	0.00	8.98E+09	-166.083	2990.	0.00
7.8000	0.1238	174377.	4357.	-0.00261	0.00	8.98E+09	-162.267	3066.	0.00
7.9950	0.1178	184719.	3982.	-0.00256	0.00	8.98E+09	-158.190	3143.	0.00
8.1900	0.1118	194183.	3617.	-0.00251	0.00	8.98E+09	-153.871	3220.	0.00
8.3850	0.1060	202794.	3262.	-0.00246	0.00	8.98E+09	-149.330	3296.	0.00
8.5800	0.1003	210574.	2918.	-0.00241	0.00	8.98E+09	-144.585	3373.	0.00
8.7750	0.09473	217551.	2585.	-0.00235	0.00	8.98E+09	-139.656	3450.	0.00
8.9700	0.08929	223750.	2265.	-0.00230	0.00	8.98E+09	-134.561	3526.	0.00
9.1650	0.08399	229199.	1956.	-0.00224	0.00	8.98E+09	-129.321	3603.	0.00
9.3600	0.07883	233926.	1660.	-0.00218	0.00	8.98E+09	-123.953	3680.	0.00
9.5550	0.07381	237960.	1376.	-0.00211	0.00	8.98E+09	-118.475	3756.	0.00
9.7500	0.06893	241331.	1105.	-0.00205	0.00	8.98E+09	-112.906	3833.	0.00
9.9450	0.06420	244070.	847.5680	-0.00199	0.00	8.98E+09	-107.264	3910.	0.00
10.1400	0.05962	246207.	603.2377	-0.00193	0.00	8.98E+09	-101.565	3986.	0.00
10.3350	0.05519	247773.	372.2882	-0.00186	0.00	8.98E+09	-95.827	4063.	0.00
10.5300	0.05091	248800.	154.7925	-0.00180	0.00	8.98E+09	-90.066	4140.	0.00
10.7250	0.04679	249319.	-49.215	-0.00173	0.00	8.98E+09	-84.299	4216.	0.00
10.9200	0.04281	249361.	-239.735	-0.00167	0.00	8.98E+09	-78.539	4293.	0.00
11.1150	0.03899	248958.	-416.806	-0.00160	0.00	8.98E+09	-72.804	4370.	0.00
11.3100	0.03532	248142.	-580.500	-0.00154	0.00	8.98E+09	-67.106	4446.	0.00
11.5050	0.03180	246944.	-730.922	-0.00147	0.00	8.98E+09	-61.460	4523.	0.00
11.7000	0.02843	245394.	-868.210	-0.00141	0.00	8.98E+09	-55.880	4600.	0.00
11.8950	0.02521	243524.	-992.531	-0.00134	0.00	8.98E+09	-50.378	4676.	0.00
12.0900	0.02214	241364.	-1104.	-0.00128	0.00	8.98E+09	-44.967	4753.	0.00
12.2850	0.01922	238942.	-1203.	-0.00122	0.00	8.98E+09	-39.658	4829.	0.00
12.4800	0.01644	236290.	-1290.	-0.00116	0.00	8.98E+09	-34.463	4906.	0.00
12.6750	0.01380	233435.	-1365.	-0.00110	0.00	8.98E+09	-29.393	4983.	0.00
12.8700	0.01131	230405.	-1428.	-0.00103	0.00	8.98E+09	-24.459	5059.	0.00
13.0650	0.00896	227227.	-2887.	-9.75E-04	0.00	8.98E+09	-1223.	319261.	0.00
13.2600	0.00675	217341.	-5420.	-9.17E-04	0.00	8.98E+09	-942.658	326835.	0.00
13.4550	0.00467	202280.	-7303.	-8.62E-04	0.00	8.98E+09	-666.911	334222.	0.00
13.6500	0.00271	183556.	-8547.	-8.12E-04	0.00	8.98E+09	-395.817	341414.	0.00
13.8450	8.68E-04	162653.	-9161.	-7.67E-04	0.00	8.98E+09	-129.302	348418.	0.00
14.0400	-8.77E-04	141033.	-9215.	-6.41E-04	0.00	1.57E+09	83.1463	221882.	0.00
14.2350	-0.00213	119819.	-8884.	-4.53E-04	0.00	1.71E+09	199.9484	219733.	0.00
14.4300	-0.00300	99663.	-8323.	-3.03E-04	0.00	1.71E+09	279.6239	218285.	0.00
14.6250	-0.00355	81007.	-7610.	-1.79E-04	0.00	1.71E+09	329.4995	217396.	0.00
14.8200	-0.00384	64130.	-6808.	-8.01E-05	0.00	1.71E+09	355.6977	216946.	0.00
15.0150	-0.00392	49181.	-5967.	-2.69E-06	0.00	1.71E+09	363.3816	216835.	0.00
15.2100	-0.00385	36206.	-5124.	5.56E-05	0.00	1.71E+09	356.9204	216981.	0.00
15.4050	-0.00366	25174.	-4309.	9.75E-05	0.00	1.71E+09	340.0075	217313.	0.00
15.6000	-0.00339	15996.	-3542.	1.26E-04	0.00	1.71E+09	315.7476	217773.	0.00
15.7950	-0.00307	8541.	-2837.	1.42E-04	0.00	1.71E+09	286.7234	218314.	0.00
15.9900	-0.00273	2654.	-2203.	1.50E-04	0.00	1.72E+09	255.0497	218898.	0.00
16.1850	-0.00237	-1837.	-1644.	1.51E-04	0.00	1.72E+09	222.4207	219493.	0.00
16.3800	-0.00202	-5109.	-1162.	1.46E-04	0.00	1.72E+09	190.1523	220077.	0.00
16.5750	-0.00169	-7339.	-752.763	1.37E-04	0.00	1.71E+09	159.2272	220632.	0.00
16.7700	-0.00138	-8695.	-413.975	1.26E-04	0.00	1.71E+09	130.3356	221148.	0.00
16.9650	-0.00110	-9335.	-139.900	1.14E-04	0.00	1.71E+09	103.9158	221616.	0.00

17.1600	-8.45E-04	-9402.	75.5083	1.01E-04	0.00	1.71E+09	80.1942	222034.	0.00
17.3550	-6.23E-04	-9027.	238.6269	8.87E-05	0.00	1.71E+09	59.2234	222402.	0.00
17.5500	-4.30E-04	-8326.	355.7928	7.69E-05	0.00	1.71E+09	40.9185	222720.	0.00
17.7450	-2.63E-04	-7398.	433.0228	6.62E-05	0.00	1.71E+09	25.0901	222994.	0.00
17.9400	-1.20E-04	-6330.	475.8034	5.68E-05	0.00	1.71E+09	11.4745	223228.	0.00
18.1350	2.51E-06	-5197.	488.9483	4.89E-05	0.00	1.72E+09	-0.240	223419.	0.00
18.3300	1.09E-04	-4064.	476.5333	4.26E-05	0.00	1.72E+09	-10.371	223248.	0.00
18.5250	2.02E-04	-2986.	441.8725	3.78E-05	0.00	1.72E+09	-19.253	223099.	0.00
18.7200	2.86E-04	-2013.	387.5023	3.44E-05	0.00	1.72E+09	-27.217	222966.	0.00
18.9150	3.63E-04	-1188.	315.2210	3.22E-05	0.00	1.72E+09	-34.562	222845.	0.00
19.1100	4.36E-04	-552.417	226.1831	3.10E-05	0.00	1.72E+09	-41.539	222730.	0.00
19.3050	5.08E-04	-143.879	121.0220	3.06E-05	0.00	1.72E+09	-48.342	222620.	0.00
19.5000	5.79E-04	0.00	0.00	3.05E-05	0.00	1.72E+09	-55.095	111255.	0.00

* This analysis computed pile response using nonlinear moment-curvature relationships. Values of total stress due to combined axial and bending stresses are computed only for elastic sections only and do not equal the actual stresses in concrete and steel. Stresses in concrete and steel may be interpolated from the output for nonlinear bending properties relative to the magnitude of bending moment developed in the pile.

Output Summary for Load Case No. 1:

Pile-head deflection = 0.33020304 inches
 Computed slope at pile head = 0.000000 radians
 Maximum bending moment = -776853. inch-lbs
 Maximum shear force = 12760. lbs
 Depth of maximum bending moment = 0.000000 feet below pile head
 Depth of maximum shear force = 0.000000 feet below pile head
 Number of iterations = 9
 Number of zero deflection points = 2

Pile-head Deflection vs. Pile Length for Load Case 1

Boundary Condition Type 2, Shear and Slope

Shear = 12760. lbs
 Slope = 0.00000
 Axial Load = 97670. lbs

Pile Length feet	Pile Head Deflection inches	Maximum Moment ln-lbs	Maximum Shear lbs
19.50000	0.33020304	-776853.	12760.
18.52500	0.33114542	-776694.	12760.
17.55000	0.33190315	-776945.	12760.
16.57500	0.33024354	-776667.	12760.
15.60000	0.33485872	-777767.	12760.
14.62500	0.35340687	-785765.	12760.
13.65000	0.38084302	-802471.	12760.
12.67500	0.43194913	-904797.	12760.
11.70000	0.44174896	-937039.	12760.
10.72500	0.44328881	-955455.	12760.
9.75000	0.44131422	-951183.	12760.
8.77500	0.45262529	-918862.	12760.
7.80000	0.53911004	-856350.	12760.

Computed Values of Pile Loading and Deflection for Lateral Loading for Load Case Number 2

Pile-head conditions are Shear and Pile-head Rotation (Loading Type 2)

Shear force at pile head = 5030.0 lbs
 Rotation of pile head = 0.000E+00 radians
 Axial load at pile head = 70520.0 lbs

(Zero slope for this load indicates fixed-head conditions)

Depth X feet	Deflect. y inches	Bending Moment in-lbs	Shear Force lbs	Slope S radians	Total Stress psi*	Bending Stiffness lb-in^2	Soil Res. p lb/inch	Soil Spr. Es*H lb/inch	Distrib. Lat. Load lb/inch
0.00	0.1041	-277889.	5030.	0.00	0.00	9.00E+09	0.00	0.00	0.00
0.1950	0.1040	-266113.	5026.	-7.07E-05	0.00	9.00E+09	-3.136	70.5355	0.00
0.3900	0.1038	-254342.	5015.	-1.38E-04	0.00	9.00E+09	-6.591	148.6251	0.00
0.5850	0.1034	-242597.	4995.	-2.03E-04	0.00	9.00E+09	-10.160	229.9752	0.00
0.7800	0.1028	-230897.	4968.	-2.64E-04	0.00	9.00E+09	-13.474	306.6336	0.00
0.9750	0.1021	-219261.	4932.	-3.23E-04	0.00	9.00E+09	-16.730	383.2920	0.00
1.1700	0.1013	-207707.	4889.	-3.78E-04	0.00	9.00E+09	-19.914	459.9504	0.00
1.3650	0.1004	-196253.	4839.	-4.31E-04	0.00	9.01E+09	-23.016	536.6088	0.00
1.5600	0.09930	-184917.	4782.	-4.80E-04	0.00	9.01E+09	-26.024	613.2672	0.00
1.7550	0.09812	-173716.	4718.	-5.27E-04	0.00	9.01E+09	-28.929	689.9256	0.00
1.9500	0.09683	-162665.	4647.	-5.71E-04	0.00	9.01E+09	-31.722	766.5840	0.00
2.1450	0.09545	-151781.	4570.	-6.12E-04	0.00	9.01E+09	-33.984	833.1688	0.00
2.3400	0.09397	-141077.	4488.	-6.50E-04	0.00	9.01E+09	-35.484	883.6316	0.00
2.5350	0.09241	-130560.	4404.	-6.85E-04	0.00	9.01E+09	-36.589	926.5393	0.00
2.7300	0.09076	-120239.	4318.	-7.18E-04	0.00	9.01E+09	-37.288	961.3341	0.00
2.9250	0.08905	-110117.	4229.	-7.47E-04	0.00	9.01E+09	-38.480	1011.	0.00
3.1200	0.08726	-100200.	4138.	-7.75E-04	0.00	9.01E+09	-39.144	1050.	0.00
3.3150	0.08542	-90494.	4047.	-8.00E-04	0.00	9.01E+09	-39.226	1075.	0.00
3.5100	0.08352	-80999.	3955.	-8.22E-04	0.00	9.01E+09	-38.684	1084.	0.00
3.7050	0.08158	-71712.	3864.	-8.42E-04	0.00	9.01E+09	-39.762	1141.	0.00
3.9000	0.07958	-62639.	3768.	-8.59E-04	0.00	9.01E+09	-42.009	1235.	0.00
4.0950	0.07755	-53794.	3667.	-8.74E-04	0.00	9.01E+09	-44.139	1332.	0.00
4.2900	0.07549	-45188.	3562.	-8.87E-04	0.00	9.01E+09	-46.136	1430.	0.00
4.4850	0.07340	-36833.	3451.	-8.98E-04	0.00	9.01E+09	-48.015	1531.	0.00
4.6800	0.07129	-28740.	3336.	-9.06E-04	0.00	9.01E+09	-50.895	1671.	0.00
4.8750	0.06916	-20923.	3213.	-9.13E-04	0.00	9.01E+09	-53.759	1819.	0.00
5.0700	0.06702	-13401.	3084.	-9.17E-04	0.00	9.01E+09	-56.596	1976.	0.00
5.2650	0.06487	-6187.	2951.	-9.20E-04	0.00	9.01E+09	-57.378	2070.	0.00
5.4600	0.06271	712.3816	2816.	-9.20E-04	0.00	9.01E+09	-57.527	2146.	0.00
5.6550	0.06056	7297.	2682.	-9.19E-04	0.00	9.01E+09	-57.535	2223.	0.00
5.8500	0.05841	13566.	2547.	-9.17E-04	0.00	9.01E+09	-57.407	2300.	0.00
6.0450	0.05627	19520.	2413.	-9.12E-04	0.00	9.01E+09	-57.146	2376.	0.00
6.2400	0.05414	25161.	2280.	-9.07E-04	0.00	9.01E+09	-56.758	2453.	0.00
6.4350	0.05203	30489.	2148.	-8.99E-04	0.00	9.01E+09	-56.246	2530.	0.00
6.6300	0.04993	35509.	2017.	-8.91E-04	0.00	9.01E+09	-55.617	2606.	0.00
6.8250	0.04786	40222.	1888.	-8.81E-04	0.00	9.01E+09	-54.875	2683.	0.00
7.0200	0.04581	44633.	1760.	-8.70E-04	0.00	9.01E+09	-54.026	2760.	0.00
7.2150	0.04379	48747.	1635.	-8.58E-04	0.00	9.01E+09	-53.076	2836.	0.00
7.4100	0.04180	52567.	1512.	-8.45E-04	0.00	9.01E+09	-52.030	2913.	0.00
7.6050	0.03983	56101.	1391.	-8.31E-04	0.00	9.01E+09	-50.894	2990.	0.00
7.8000	0.03791	59353.	1274.	-8.16E-04	0.00	9.01E+09	-49.675	3066.	0.00
7.9950	0.03602	62331.	1159.	-8.00E-04	0.00	9.01E+09	-48.378	3143.	0.00
8.1900	0.03417	65041.	1047.	-7.83E-04	0.00	9.01E+09	-47.009	3220.	0.00
8.3850	0.03235	67491.	939.0956	-7.66E-04	0.00	9.01E+09	-45.575	3296.	0.00
8.5800	0.03058	69689.	834.1991	-7.48E-04	0.00	9.01E+09	-44.081	3373.	0.00
8.7750	0.02885	71642.	732.8614	-7.30E-04	0.00	9.01E+09	-42.533	3450.	0.00
8.9700	0.02717	73360.	635.2012	-7.11E-04	0.00	9.01E+09	-40.937	3526.	0.00
9.1650	0.02552	74850.	541.3231	-6.92E-04	0.00	9.01E+09	-39.300	3603.	0.00
9.3600	0.02393	76121.	451.3181	-6.72E-04	0.00	9.01E+09	-37.627	3680.	0.00
9.5550	0.02238	77184.	365.2636	-6.52E-04	0.00	9.01E+09	-35.924	3756.	0.00
9.7500	0.02088	78046.	283.2240	-6.32E-04	0.00	9.01E+09	-34.196	3833.	0.00
9.9450	0.01942	78718.	205.2505	-6.12E-04	0.00	9.01E+09	-32.448	3910.	0.00
10.1400	0.01801	79208.	131.3817	-5.91E-04	0.00	9.01E+09	-30.687	3986.	0.00
10.3350	0.01665	79528.	61.6437	-5.70E-04	0.00	9.01E+09	-28.918	4063.	0.00
10.5300	0.01534	79685.	-3.949	-5.50E-04	0.00	9.01E+09	-27.145	4140.	0.00
10.7250	0.01408	79691.	-65.395	-5.29E-04	0.00	9.01E+09	-25.373	4216.	0.00

10.9200	0.01287	79554.	-122.702	-5.08E-04	0.00	9.01E+09	-23.607	4293.	0.00
11.1150	0.01170	79284.	-175.890	-4.88E-04	0.00	9.01E+09	-21.853	4370.	0.00
11.3100	0.01059	78892.	-224.990	-4.67E-04	0.00	9.01E+09	-20.113	4446.	0.00
11.5050	0.00952	78385.	-270.042	-4.47E-04	0.00	9.01E+09	-18.393	4523.	0.00
11.7000	0.00849	77775.	-311.097	-4.26E-04	0.00	9.01E+09	-16.697	4600.	0.00
11.8950	0.00752	77070.	-348.215	-4.06E-04	0.00	9.01E+09	-15.028	4676.	0.00
12.0900	0.00659	76280.	-381.464	-3.86E-04	0.00	9.01E+09	-13.390	4753.	0.00
12.2850	0.00571	75413.	-410.923	-3.67E-04	0.00	9.01E+09	-11.788	4829.	0.00
12.4800	0.00488	74478.	-436.676	-3.47E-04	0.00	9.01E+09	-10.224	4906.	0.00
12.6750	0.00409	73483.	-458.818	-3.28E-04	0.00	9.01E+09	-8.701	4983.	0.00
12.8700	0.00334	72439.	-477.450	-3.09E-04	0.00	9.01E+09	-7.224	5059.	0.00
13.0650	0.00264	71351.	-937.053	-2.90E-04	0.00	9.01E+09	-385.599	341820.	0.00
13.2600	0.00198	68149.	-1729.	-2.72E-04	0.00	9.01E+09	-291.650	344360.	0.00
13.4550	0.00137	63347.	-2307.	-2.55E-04	0.00	9.01E+09	-202.329	346753.	0.00
13.6500	7.87E-04	57435.	-2682.	-2.40E-04	0.00	9.01E+09	-117.447	349006.	0.00
13.8450	2.44E-04	50877.	-2862.	-2.25E-04	0.00	9.01E+09	-36.681	351130.	0.00
14.0400	-2.68E-04	44116.	-2875.	-1.90E-04	0.00	1.78E+09	25.7842	225445.	0.00
14.2350	-6.44E-04	37486.	-2772.	-1.36E-04	0.00	1.78E+09	61.8812	224773.	0.00
14.4300	-9.06E-04	31187.	-2598.	-9.13E-05	0.00	1.78E+09	86.8202	224315.	0.00
14.6250	-0.00107	25357.	-2376.	-5.42E-05	0.00	1.78E+09	102.5756	224031.	0.00
14.8200	-0.00116	20084.	-2127.	-2.44E-05	0.00	1.78E+09	110.9154	223886.	0.00
15.0150	-0.00119	15413.	-1864.	-1.09E-06	0.00	1.78E+09	113.4040	223850.	0.00
15.2100	-0.00116	11359.	-1601.	1.65E-05	0.00	1.78E+09	111.4071	223895.	0.00
15.4050	-0.00111	7914.	-1347.	2.91E-05	0.00	1.78E+09	106.1008	224000.	0.00
15.6000	-0.00103	5047.	-1107.	3.76E-05	0.00	1.78E+09	98.4812	224146.	0.00
15.7950	-9.32E-04	2719.	-887.555	4.27E-05	0.00	1.78E+09	89.3771	224318.	0.00
15.9900	-8.28E-04	879.2426	-690.011	4.51E-05	0.00	1.79E+09	79.4635	224503.	0.00
16.1850	-7.21E-04	-525.360	-515.987	4.53E-05	0.00	1.79E+09	69.2755	224691.	0.00
16.3800	-6.16E-04	-1551.	-365.642	4.39E-05	0.00	1.79E+09	59.2241	224875.	0.00
16.5750	-5.16E-04	-2251.	-238.305	4.14E-05	0.00	1.79E+09	49.6116	225049.	0.00
16.7700	-4.22E-04	-2679.	-132.703	3.82E-05	0.00	1.78E+09	40.6463	225211.	0.00
16.9650	-3.37E-04	-2885.	-47.171	3.46E-05	0.00	1.78E+09	32.4576	225358.	0.00
17.1600	-2.61E-04	-2912.	20.1817	3.08E-05	0.00	1.78E+09	25.1092	225489.	0.00
17.3550	-1.93E-04	-2800.	71.3357	2.70E-05	0.00	1.78E+09	18.6122	225604.	0.00
17.5500	-1.34E-04	-2587.	108.2475	2.35E-05	0.00	1.79E+09	12.9364	225704.	0.00
17.7450	-8.31E-05	-2302.	132.7672	2.03E-05	0.00	1.79E+09	8.0207	225790.	0.00
17.9400	-3.92E-05	-1972.	146.5770	1.75E-05	0.00	1.79E+09	3.7825	225863.	0.00
18.1350	-1.30E-06	-1621.	151.1494	1.51E-05	0.00	1.79E+09	0.1255	225926.	0.00
18.3300	3.16E-05	-1270.	147.7259	1.32E-05	0.00	1.79E+09	-3.052	225876.	0.00
18.5250	6.06E-05	-934.383	137.3089	1.18E-05	0.00	1.79E+09	-5.852	225829.	0.00
18.7200	8.68E-05	-630.945	120.6646	1.08E-05	0.00	1.79E+09	-8.374	225786.	0.00
18.9150	1.11E-04	-373.225	98.3369	1.01E-05	0.00	1.79E+09	-10.709	225747.	0.00
19.1100	1.34E-04	-174.064	70.6751	9.75E-06	0.00	1.79E+09	-12.933	225710.	0.00
19.3050	1.57E-04	-45.682	37.8703	9.60E-06	0.00	1.79E+09	-15.105	225674.	0.00
19.5000	1.79E-04	0.00	0.00	9.57E-06	0.00	1.79E+09	-17.263	112820.	0.00

* This analysis computed pile response using nonlinear moment-curvature relationships. Values of total stress due to combined axial and bending stresses are computed only for elastic sections only and do not equal the actual stresses in concrete and steel. Stresses in concrete and steel may be interpolated from the output for nonlinear bending properties relative to the magnitude of bending moment developed in the pile.

Output Summary for Load Case No. 2:

Pile-head deflection = 0.10410657 inches
 Computed slope at pile head = 0.000000 radians
 Maximum bending moment = -277889. inch-lbs
 Maximum shear force = 5030. lbs
 Depth of maximum bending moment = 0.000000 feet below pile head
 Depth of maximum shear force = 0.000000 feet below pile head
 Number of iterations = 6
 Number of zero deflection points = 2

 Pile-head Deflection vs. Pile Length for Load Case 2

Boundary Condition Type 2, Shear and Slope

Shear = 5030. lbs
Slope = 0.00000
Axial Load = 70520. lbs

Pile Length feet	Pile Head Deflection inches	Maximum Moment ln-lbs	Maximum Shear lbs
19.50000	0.10410657	-277889.	5030.
18.52500	0.10431728	-277704.	5030.
17.55000	0.10447498	-277697.	5030.
16.57500	0.10413736	-277787.	5030.
15.60000	0.10513763	-277682.	5030.
14.62500	0.10902667	-278482.	5030.
13.65000	0.11511986	-281630.	5030.
12.67500	0.12778521	-312220.	5030.
11.70000	0.13069030	-322378.	5030.
10.72500	0.13164016	-329311.	5030.
9.75000	0.13131161	-329820.	5030.
8.77500	0.13251109	-321870.	5030.
7.80000	0.14138400	-305417.	5030.
6.82500	0.17681172	-280096.	5030.
5.85000	0.29465070	-242346.	5030.

Computed Values of Pile Loading and Deflection
for Lateral Loading for Load Case Number 3

Pile-head conditions are Displacement and Pile-head Rotation (Loading Type 5)
Displacement of pile head = 1.000000 inches
Rotation of pile head = 0.000E+00 radians
Axial load on pile head = 70520.0 lbs

Depth X feet	Deflect. y inches	Bending Moment in-lbs	Shear Force lbs	Slope S radians	Total Stress psi*	Bending Stiffness lb-in^2	Soil Res. p lb/inch	Soil Spr. Es*H lb/inch	Distrib. Lat. Load lb/inch
0.00	1.0000	-1927607.	27972.	0.00	0.00	7.92E+09	0.00	0.00	0.00
0.1950	0.9993	-1862120.	27960.	-5.60E-04	0.00	7.92E+09	-4.845	11.3449	0.00
0.3900	0.9974	-1796570.	27942.	-0.00110	0.00	7.94E+09	-10.372	24.3347	0.00
0.5850	0.9942	-1730989.	27911.	-0.00162	0.00	7.95E+09	-16.316	38.4027	0.00
0.7800	0.9898	-1665413.	27865.	-0.00212	0.00	7.96E+09	-22.429	53.0246	0.00
0.9750	0.9843	-1599879.	27806.	-0.00260	0.00	7.97E+09	-28.535	67.8388	0.00
1.1700	0.9776	-1534424.	27732.	-0.00306	0.00	7.98E+09	-34.473	82.5108	0.00
1.3650	0.9700	-1469084.	27645.	-0.00350	0.00	7.99E+09	-40.043	96.6011	0.00
1.5600	0.9613	-1403892.	27545.	-0.00392	0.00	8.01E+09	-45.744	111.3533	0.00
1.7550	0.9516	-1338882.	27431.	-0.00432	0.00	8.02E+09	-50.905	125.1727	0.00
1.9500	0.9411	-1274087.	27307.	-0.00470	0.00	8.03E+09	-55.772	138.6788	0.00
2.1450	0.9296	-1209536.	27171.	-0.00506	0.00	8.05E+09	-59.998	151.0204	0.00
2.3400	0.9174	-1145256.	27026.	-0.00540	0.00	8.06E+09	-64.307	164.0301	0.00
2.5350	0.9044	-1081273.	26870.	-0.00573	0.00	8.08E+09	-68.890	178.2509	0.00
2.7300	0.8906	-1017615.	26703.	-0.00603	0.00	8.10E+09	-73.443	192.9683	0.00
2.9250	0.8761	-954311.	26524.	-0.00631	0.00	8.12E+09	-79.813	213.1640	0.00
3.1200	0.8610	-891399.	26330.	-0.00658	0.00	8.14E+09	-86.060	233.8796	0.00
3.3150	0.8454	-828915.	26122.	-0.00683	0.00	8.17E+09	-92.135	255.0355	0.00
3.5100	0.8291	-766897.	25899.	-0.00705	0.00	8.20E+09	-97.985	276.5441	0.00
3.7050	0.8123	-705380.	25661.	-0.00726	0.00	8.23E+09	-105.801	304.7657	0.00
3.9000	0.7951	-644408.	25402.	-0.00745	0.00	8.27E+09	-115.191	339.0052	0.00
4.0950	0.7775	-584037.	25121.	-0.00763	0.00	8.31E+09	-124.919	375.9831	0.00
4.2900	0.7594	-524323.	24817.	-0.00778	0.00	8.36E+09	-134.977	415.9102	0.00
4.4850	0.7410	-465324.	24489.	-0.00792	0.00	8.42E+09	-145.382	459.0862	0.00
4.6800	0.7223	-407100.	24135.	-0.00804	0.00	8.50E+09	-156.862	508.1514	0.00

4.8750	0.7034	-349716.	23754.	-0.00815	0.00	8.59E+09	-168.771	561.4619	0.00
5.0700	0.6842	-293241.	23345.	-0.00823	0.00	9.00E+09	-181.111	619.3958	0.00
5.2650	0.6649	-237744.	22906.	-0.00830	0.00	9.00E+09	-193.880	682.3660	0.00
5.4600	0.6454	-183299.	22437.	-0.00836	0.00	9.01E+09	-207.079	750.8384	0.00
5.6550	0.6258	-129980.	21937.	-0.00840	0.00	9.01E+09	-220.708	825.3309	0.00
5.8500	0.6061	-77864.	21404.	-0.00842	0.00	9.01E+09	-234.767	906.4207	0.00
6.0450	0.5863	-27030.	20838.	-0.00844	0.00	9.01E+09	-249.256	994.7512	0.00
6.2400	0.5666	22440.	20237.	-0.00844	0.00	9.01E+09	-264.175	1091.	0.00
6.4350	0.5468	70463.	19601.	-0.00843	0.00	9.01E+09	-279.524	1196.	0.00
6.6300	0.5272	116952.	18928.	-0.00840	0.00	9.01E+09	-295.302	1311.	0.00
6.8250	0.5075	161819.	18218.	-0.00836	0.00	9.01E+09	-311.511	1436.	0.00
7.0200	0.4880	204974.	17470.	-0.00832	0.00	9.00E+09	-328.149	1573.	0.00
7.2150	0.4686	246323.	16682.	-0.00826	0.00	9.00E+09	-345.218	1724.	0.00
7.4100	0.4494	285771.	15854.	-0.00819	0.00	9.00E+09	-362.716	1889.	0.00
7.6050	0.4303	323220.	14984.	-0.00811	0.00	8.64E+09	-380.644	2070.	0.00
7.8000	0.4114	358571.	14072.	-0.00802	0.00	8.57E+09	-399.002	2269.	0.00
7.9950	0.3928	391722.	13126.	-0.00791	0.00	8.52E+09	-409.440	2439.	0.00
8.1900	0.3744	422612.	12164.	-0.00780	0.00	8.48E+09	-412.778	2580.	0.00
8.3850	0.3563	451223.	11195.	-0.00768	0.00	8.44E+09	-415.384	2728.	0.00
8.5800	0.3384	477539.	10221.	-0.00755	0.00	8.41E+09	-417.262	2885.	0.00
8.7750	0.3209	501548.	9243.	-0.00741	0.00	8.38E+09	-418.420	3051.	0.00
8.9700	0.3037	523243.	8263.	-0.00727	0.00	8.36E+09	-418.867	3227.	0.00
9.1650	0.2869	542620.	7283.	-0.00712	0.00	8.35E+09	-418.617	3414.	0.00
9.3600	0.2704	559680.	6305.	-0.00697	0.00	8.33E+09	-417.683	3615.	0.00
9.5550	0.2543	574427.	5339.	-0.00681	0.00	8.32E+09	-408.179	3756.	0.00
9.7500	0.2385	586913.	4404.	-0.00664	0.00	8.31E+09	-390.723	3833.	0.00
9.9450	0.2232	597231.	3511.	-0.00648	0.00	8.30E+09	-372.883	3910.	0.00
10.1400	0.2082	605480.	2659.	-0.00631	0.00	8.29E+09	-354.707	3986.	0.00
10.3350	0.1937	611759.	1851.	-0.00614	0.00	8.29E+09	-336.245	4063.	0.00
10.5300	0.1795	616168.	1086.	-0.00596	0.00	8.29E+09	-317.543	4140.	0.00
10.7250	0.1657	618809.	365.0469	-0.00579	0.00	8.29E+09	-298.648	4216.	0.00
10.9200	0.1524	619787.	-311.505	-0.00561	0.00	8.28E+09	-279.601	4293.	0.00
11.1150	0.1395	619204.	-943.360	-0.00544	0.00	8.28E+09	-260.446	4370.	0.00
11.3100	0.1270	617167.	-1530.	-0.00526	0.00	8.29E+09	-241.221	4446.	0.00
11.5050	0.1148	613780.	-2072.	-0.00509	0.00	8.29E+09	-221.964	4523.	0.00
11.7000	0.1031	609149.	-2569.	-0.00492	0.00	8.29E+09	-202.710	4600.	0.00
11.8950	0.09182	603380.	-3021.	-0.00475	0.00	8.30E+09	-183.492	4676.	0.00
12.0900	0.08091	596578.	-3428.	-0.00458	0.00	8.30E+09	-164.342	4753.	0.00
12.2850	0.07040	588848.	-3790.	-0.00441	0.00	8.31E+09	-145.290	4829.	0.00
12.4800	0.06027	580295.	-4108.	-0.00425	0.00	8.31E+09	-126.363	4906.	0.00
12.6750	0.05052	571024.	-4382.	-0.00408	0.00	8.32E+09	-107.586	4983.	0.00
12.8700	0.04115	561137.	-4612.	-0.00393	0.00	8.33E+09	-88.982	5059.	0.00
13.0650	0.03215	550736.	-8860.	-0.00377	0.00	8.34E+09	-3542.	257761.	0.00
13.2600	0.02351	520916.	-16273.	-0.00362	0.00	8.37E+09	-2794.	278043.	0.00
13.4550	0.01522	475774.	-21829.	-0.00348	0.00	8.41E+09	-1954.	300542.	0.00
13.6500	0.00723	419907.	-25292.	-0.00336	0.00	8.48E+09	-1006.	325673.	0.00
13.8450	-4.89E-04	358513.	-26384.	-0.00325	0.00	8.57E+09	73.1840	350200.	0.00
14.0400	-0.00798	297504.	-25451.	-0.00236	0.00	4.14E+08	723.9713	212363.	0.00
14.2350	-0.01153	240182.	-23411.	-0.00106	0.00	6.09E+08	1019.	206899.	0.00
14.4300	-0.01292	188289.	-20894.	-3.34E-04	0.00	8.45E+08	1132.	204899.	0.00
14.6250	-0.01310	142506.	-18230.	6.05E-05	0.00	1.24E+09	1146.	204730.	0.00
14.8200	-0.01264	102952.	-15591.	2.63E-04	0.00	1.78E+09	1110.	205485.	0.00
15.0150	-0.01187	69453.	-13066.	3.76E-04	0.00	1.78E+09	1048.	206707.	0.00
15.2100	-0.01088	41678.	-10707.	4.49E-04	0.00	1.78E+09	968.1800	208252.	0.00
15.4050	-0.00976	19196.	-8549.	4.89E-04	0.00	1.78E+09	876.2589	210000.	0.00
15.6000	-0.00859	1508.	-6614.	5.03E-04	0.00	1.79E+09	777.7225	211851.	0.00
15.7950	-0.00741	-11923.	-4912.	4.96E-04	0.00	1.78E+09	676.9809	213727.	0.00
15.9900	-0.00627	-21644.	-3444.	4.74E-04	0.00	1.78E+09	577.6132	215561.	0.00
16.1850	-0.00519	-28197.	-2204.	4.41E-04	0.00	1.78E+09	482.4281	217306.	0.00
16.3800	-0.00421	-32102.	-1179.	4.01E-04	0.00	1.78E+09	393.5172	218924.	0.00
16.5750	-0.00332	-33846.	-353.046	3.58E-04	0.00	1.78E+09	312.3166	220392.	0.00
16.7700	-0.00253	-33873.	292.7864	3.14E-04	0.00	1.78E+09	239.6766	221696.	0.00
16.9650	-0.00185	-32580.	779.0577	2.70E-04	0.00	1.78E+09	175.9400	222834.	0.00
17.1600	-0.00127	-30316.	1127.	2.29E-04	0.00	1.78E+09	121.0267	223808.	0.00
17.3550	-7.76E-04	-27383.	1355.	1.91E-04	0.00	1.78E+09	74.5192	224628.	0.00
17.5500	-3.71E-04	-24036.	1484.	1.57E-04	0.00	1.78E+09	35.7469	225307.	0.00
17.7450	-4.00E-05	-20489.	1531.	1.28E-04	0.00	1.78E+09	3.8643	225861.	0.00
17.9400	2.28E-04	-16915.	1509.	1.04E-04	0.00	1.78E+09	-22.004	225549.	0.00
18.1350	4.45E-04	-13459.	1434.	8.36E-05	0.00	1.78E+09	-42.795	225193.	0.00

18.3300	6.20E-04	-10234.	1314.	6.81E-05	0.00	1.78E+09	-59.569	224908.	0.00
18.5250	7.63E-04	-7332.	1158.	5.66E-05	0.00	1.78E+09	-73.302	224678.	0.00
18.7200	8.85E-04	-4831.	973.3359	4.86E-05	0.00	1.78E+09	-84.864	224486.	0.00
18.9150	9.91E-04	-2793.	762.9012	4.36E-05	0.00	1.78E+09	-94.995	224319.	0.00
19.1100	0.00109	-1275.	529.7292	4.09E-05	0.00	1.79E+09	-104.297	224168.	0.00
19.3050	0.00118	-327.544	275.2379	3.99E-05	0.00	1.79E+09	-113.217	224024.	0.00
19.5000	0.00128	0.00	0.00	3.97E-05	0.00	1.79E+09	-122.030	111942.	0.00

* This analysis computed pile response using nonlinear moment-curvature relationships. Values of total stress due to combined axial and bending stresses are computed only for elastic sections only and do not equal the actual stresses in concrete and steel. Stresses in concrete and steel may be interpolated from the output for nonlinear bending properties relative to the magnitude of bending moment developed in the pile.

Output Summary for Load Case No. 3:

Pile-head deflection = 1.00000000 inches
 Computed slope at pile head = 0.000000 radians
 Maximum bending moment = -1927607. inch-lbs
 Maximum shear force = 27972. lbs
 Depth of maximum bending moment = 0.000000 feet below pile head
 Depth of maximum shear force = 0.000000 feet below pile head
 Number of iterations = 13
 Number of zero deflection points = 2

Summary of Pile-head Responses for Conventional Analyses

Definitions of Pile-head Loading Conditions:

Load Type 1: Load 1 = Shear, V, lbs, and Load 2 = Moment, M, in-lbs
 Load Type 2: Load 1 = Shear, V, lbs, and Load 2 = Slope, S, radians
 Load Type 3: Load 1 = Shear, V, lbs, and Load 2 = Rot. Stiffness, R, in-lbs/rad.
 Load Type 4: Load 1 = Top Deflection, y, inches, and Load 2 = Moment, M, in-lbs
 Load Type 5: Load 1 = Top Deflection, y, inches, and Load 2 = Slope, S, radians

Load Case No.	Load Type 1	Pile-head Load 1	Load Type 2	Pile-head Load 2	Axial Loading lbs	Pile-head Deflection inches	Pile-head Rotation radians	Max Shear in Pile lbs	Max Moment in Pile in-lbs
1	V, lb	12760.	S, rad	0.00	97670.	0.3302	0.00	12760.	-776853.
2	V, lb	5030.	S, rad	0.00	70520.	0.1041	0.00	5030.	-277889.
3	y, in	1.0000	S, rad	0.00	70520.	1.0000	0.00	27972.	-1927607.

Maximum pile-head deflection = 1.000000000 inches
 Maximum pile-head rotation = -0.000000000 radians = -0.000000 deg.

The analysis ended normally.

LAMSON ENGINEERING CORPORATION		Final Page No:	
Project:	Bridge No. W-38-003, Wilmington	Job No:	Preliminary Sheet No:
Subject:	Wingwall Type 2 - 10.75 Dia. Micropile	Prepared by: SL	Date: 5/2023
Detail:	Summary of Micropile Resistance	Checked by: JG	Date: 5/2023

Summary of Micropile Resistance - Retaining Wall Type 2

Steel Casing: 10.75 in. O.D. x 0.595 in., $F_y = 52$ ksi, Wall Thickness = 0.595 in.

Steel Reinforcing Bar: #14, Threaded, Grade 60

Compressive strength of micropile grout at 28 days: $f'_c = 5$ ksi

Rock Socket Diameter = 9.56 in.

Estimated Bonded Length into Rock (Grout into intact bedrock) = 5.5 ft.

Plunge Length (Casing into Intact Bedrock) = 1 ft

Nominal Geotechnical Pile Resistance per Pile = 297.3 kips

Side Resistance Factor, ϕ_{stat} = 0.55

Factored Geotechnical Pile Resistance per Pile = 163.5 kips > 138.4 k OK

Nominal Uplift Resistance per Pile = 148.7 kips

Resistance Factor, ϕ_{up} = 0.55

Factored Uplift Resistance per Pile = 81.8 kips > 54.6 k OK

Nominal Structural Pile Resistance per Pile = 1096.9 k (Portion of Cased Length)

Nominal Structural Pile Resistance per Pile = 366.0 k (Portion of Uncased Length)

Compression Resistance Factor, ϕ_C = 0.75

Factored Structural Pile Resistance per Pile = 822.7 k (Portion of Cased Length)

Factored Structural Pile Resistance per Pile = 274.5 k (Portion of Uncased Length)

LAMSON ENGINEERING CORPORATION		Final Page No:	
Project:	Bridge No. W-38-003, Wilmington	Job No:	Preliminary Sheet No:
Subject:	Wingwall Type 2 - 10.75 Dia. Micropile	Prepared by: SL	Date: 5/2023
Detail:	Summary of Micropile Resistance	Checked by: JG	Date: 5/2023

Nominal Tension Resistance = 995.0 k (Portion of Cased Length)

Nominal Tension Resistance = 135.1 k (Portion of Uncased Length)

Tension Resistance Factor, ϕ_T = 0.8

Factored Tension Resistance = 796.0 k (Portion of Cased Length)

Factored Tension Resistance = 108.1 k (Portion of Uncased Length)

LAMSON ENGINEERING CORPORATION			Final Page No:	
Project:	Bridge No. W-38-003, Wilmington	Job No:	Preliminary Sheet No:	
Subject:	Wingwall Type 2 - 10.75 Dia. Micropile	Prepared by:	SL	Date: 12/2022
Detail:	Micropile Vertical Resistance	Checked by:	JG	Date: 12/2022

Axial Compression Resistance

Based on Boring BB-1 $O.D.$ = 10.75 in. t_{wall} = 0.595 in.

$$R_R = \text{Factored Resistance of a micropile}$$

$$= \phi R_n = \phi_{qp} R_p + \phi_{qs} R_s$$

in which:

$$R_p = q_p A_p$$

$$R_s = q_s A_s$$

where:

$$R_p = \text{nominal tip resistance}$$

(Per AASHTO C10.9.3.5.1, tip resistance is neglected for conservative)

$$R_s = \text{nominal grout to ground bond resistance}$$

$$\phi_{qp} = \text{resistance factor for tip resistance}$$

$$= 0.50 \quad (\text{AASHTO 10.5.5.2.5-1})$$

(Note: No tip resistance considered in this calculation.)

$$\phi_{qs} = \text{resistance factor for grout-to-ground resistance}$$

$$= 0.55 \quad (\text{AASHTO 10.5.5.2.5-1})$$

$$d_p = \text{diameter of micropile tip}$$

$$= 9.56 \text{ in.}$$

$$A_p = \text{area of micropile tip} = \pi D^2/4$$

$$= 71.78 \text{ in.}^2 = 0.50 \text{ ft}^2$$

$$R_s = \pi d_b \alpha_b L_b$$

in which:

$$d_b = \text{diameter of micropile drill hole through bonded length}$$

$$= 9.56 \text{ in.} = 0.80 \text{ ft}$$

$$\alpha_b = \text{nominal micropile grout-to-ground bond strength}$$





$$= 21.6 \text{ ksf for Type A Diorite}$$

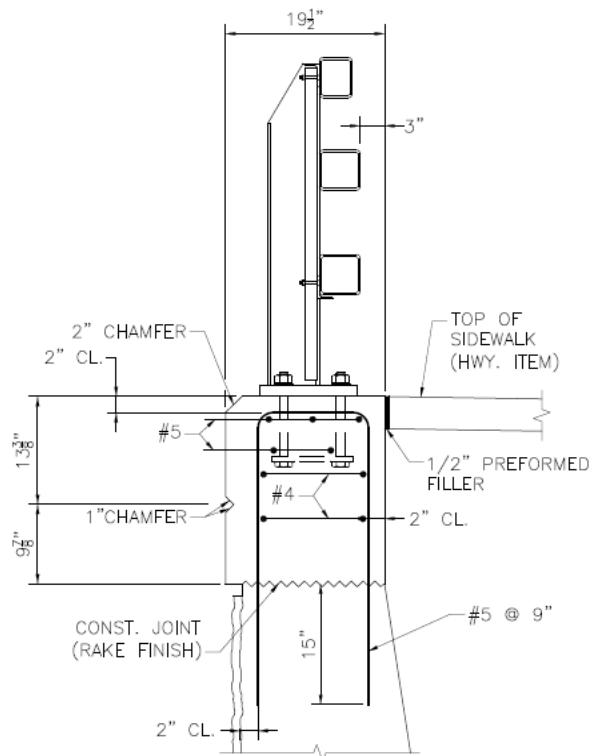
(AASHTO Table C10.9.3.5.2 - 1)

LAMSON ENGINEERING CORPORATION		Final Page No.:	
Project: Bridge No. W-38-003	Job No.:	Preliminary Sheet No.:	
Subject: Retaining Wall 2	Prepared by: SL	Date: 5/2023	
Detail: Unfactored Vertical Load	Checked by: JG	Date: 5/2023	

Retaining Wall Type 2

Unfactored Vertical Load

	W (ft)	H (ft)	unit weight		
Coping	(1.63)	(1.94)	(0.15 kcf)	=	0.47 k/ft
Stem 	(1.54)	(13.81)	(0.15 kcf)	=	3.19 k/ft
Stem 	0.5 (1.15)	(13.81)	(0.15 kcf)	=	1.19 k/ft
Concrete Footing	(8.00)	(3.00)	(0.15 kcf)	=	3.60 k/ft
Vertical Soil 1 	0.5 (1.15)	(15.75)	(0.12 kcf)	=	1.09 k/ft
Vertical Soil 2 	(3.35)	(15.75)	(0.12 kcf)	=	6.33 k/ft
Bridge Railing S3-TL4 at Sidewalk				=	0.090 k/ft



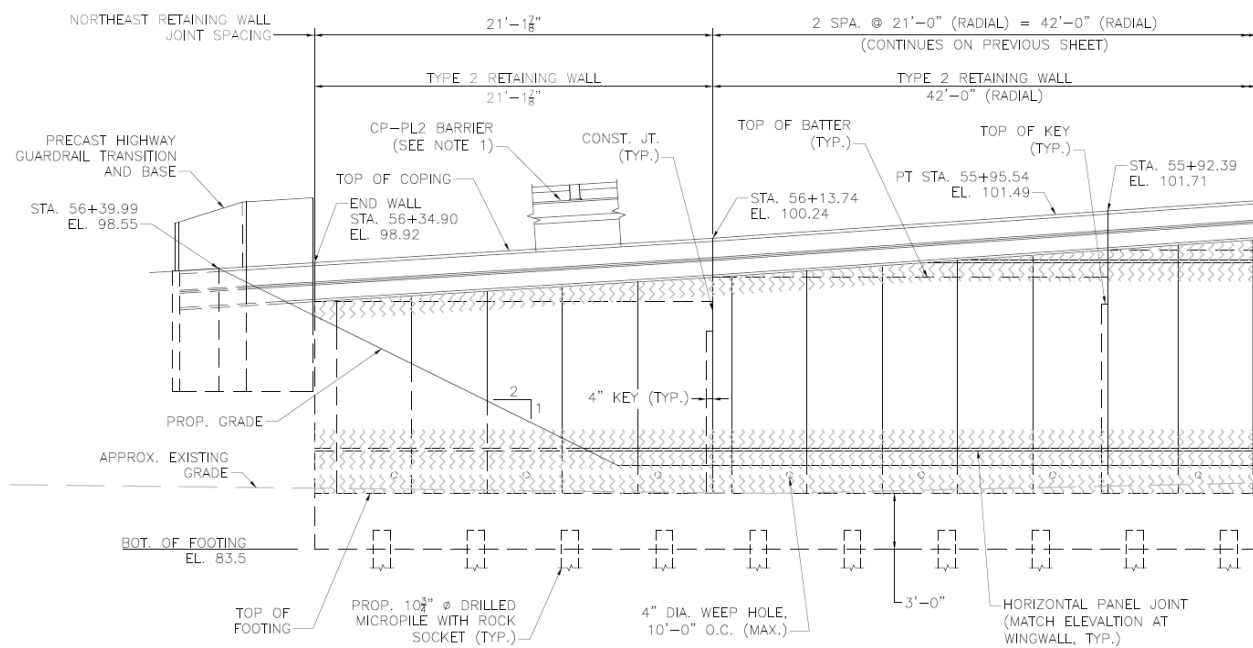
TOP OF U-WINGWALL/RETAINING WALL
DETAILS AT SIDEWALK

LAMSON ENGINEERING CORPORATION		Final Page No.:	
Project:	Bridge No. W-38-003	Job No.:	Preliminary Sheet No.:
Subject:	Retaining Wall 2	Prepared by: SL	Date: 5/2023
Detail:	Unfactored Vertical Load	Checked by: JG	Date: 5/2023

Retaining Wall Type 2

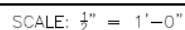
STA.	Elevation	STA.	Elevation	Length (ft.)	Bottom of Footing Elevation	Design H at highest 1/4 point (ft)	
53+80.18	106.02	53+57.93	104.66	22.3	87	18.68	SW Retaining Wall
55+10.84	106.8	55+31.50	105.81	23.0	90.5	16.05	SE Retaining Wall
52+90.54	99.18	52+66.45	97.45	24.0	82	16.75	NW Retaining Wall
55+68.70	103.36	56+34.90	98.92	63.2	83.5	18.75	NE Retaining Wall

By Investigations above, Northeast Retaining Wall could provide the control values for Micropile Design.



ELEVATION - NORTHEAST RETAINING WALL (CONT'D)

RETAINING WALL TYPE 2 AND 3 DIMENSIONS						
WALL TYPE	T	W	BAR "A"	BAR "B"	DIM "A"	DIM "B"
2	3'-0"	8'-0"	#8 @ 12"	#8 @ 9"	3'-9"	15"
3	2'-6"	8'-0"	#7 @ 12"	#6 @ 9"	2'-3"	12"



LAMSON ENGINEERING CORPORATION		Final Page No.:
Project: Bridge No. W-38-003	Job No.:	Preliminary Sheet No.:
Subject: Retaining Wall 2	Prepared by: SL	Date: 5/2023
Detail: Lateral earth pressure	Checked by: JG	Date: 5/2023

Determine Unfactored Horizontal Load

Effective angle of internal friction ϕ'_f	=	37	degree
Friction angle between fill and wall, δ	=	0	degree
Angle of fill to the horizontal, β	=	0.00	degree
Angle of back of wall to the horizontal, θ	=	90	degree
Unit weight of soil, γ_{soil}	=	0.125	kcf
Total unit weight of water, γ_w	=	0.0624	kcf
Height of Soil	=	18.75	ft ±
Distance from back of wall to footing heel, B_{heel}	=	4.50	ft
Height of fill behind footing at heel, $h = H + B_{heel} \tan \beta$	=	18.75	ft ±
Height of water from bottom of footing, H_w	=	0	ft

Lateral Earth Pressure (EH)

$$K_a = \frac{\sin^2(\theta + \phi'_f)}{\sin^2\theta \sin(\theta - \delta) \left[1 + \sqrt{\frac{\sin(\phi'_f + \delta) \sin(\phi'_f - \beta)}{\sin(\theta - \delta) \sin(\theta + \beta)}} \right]^2}$$

$$= 0.249$$

$$K_o = 1 - \sin \phi'_f = 1 - \sin(37)$$

$$= 0.398$$

Per *massDOT* LRFD BM 3.1.5

Founded on Pile = Y (Input Y if yes)

$$K_e = K_o = 0.398$$

$$P_{e1} = 0.5 K_e \gamma_{soil} (h - H_w)^2$$

$$= 0.5 \times 0.398 \times 0.125 \text{ kcf} \times (18.75 \text{ ft} - 0 \text{ ft})^2$$

$$= 8.75 \text{ k/ft length of wall}$$

$$P_{ev1} = P_{e1} \sin(90 - \theta + \delta)$$

$$= 8.75 \text{ k/ft} \times \sin(90 - 90 + 0)$$

$$= 0.00 \text{ k/ft}$$

LAMSON ENGINEERING CORPORATION		Final Page No.:
Project: Bridge No. W-38-003	Job No.:	Preliminary Sheet No.:
Subject: Retaining Wall 2	Prepared by: SL	Date: 5/2023
Detail: Lateral earth pressure	Checked by: JG	Date: 5/2023

$$\begin{aligned}
 \text{Horizontal component of } P_{e1}, P_{eh1} &= P_{e1} \cos (90 - \theta + \delta) \\
 &= 8.75 \text{ k/ft} \times \cos (90 - 90 + 0) \\
 &= 8.75 \text{ k/ft}
 \end{aligned}$$

$$\begin{aligned}
 \text{Lateral earth pressure, } P_{e2} &= K_e \gamma_{\text{soil}} (h - H_w) H_w \\
 &= 0.398 \times 0.125 \text{ kcf} \times (18.75 \text{ ft} - 0 \text{ ft}) \times 0 \text{ ft} \\
 &= 0.00 \text{ k/ft length of wall}
 \end{aligned}$$

$$\begin{aligned}
 \text{Vertical component of } P_{e2}, P_{ev2} &= P_{e2} \sin (90 - \theta + \delta) \\
 &= 0 \text{ k/ft} \times \sin (90 - 90 + 0) \\
 &= 0.00 \text{ k/ft}
 \end{aligned}$$

$$\begin{aligned}
 \text{Horizontal component of } P_{e2}, P_{eh2} &= P_{e2} \cos (90 - \theta + \delta) \\
 &= 0 \text{ k/ft} \times \cos (90 - 90 + 0) \\
 &= 0.00 \text{ k/ft}
 \end{aligned}$$

$$\begin{aligned}
 \text{Lateral earth pressure, } P_{e3} &= 0.5 K_e \gamma' (H_w)^2 \\
 &= 0.5 \times 0.398 \times (0.125 \text{ kcf} - 0.0624 \text{ kcf}) \times 0 \text{ ft}^2 \\
 &= 0.00 \text{ k/ft length of wall}
 \end{aligned}$$

$$\begin{aligned}
 \text{Vertical component of } P_{e3}, P_{ev3} &= P_{e3} \sin (90 - \theta + \delta) \\
 &= 0 \text{ k/ft} \times \sin (90 - 90 + 0) \\
 &= 0.00 \text{ k/ft}
 \end{aligned}$$

$$\begin{aligned}
 \text{Horizontal component of } P_{e3}, P_{eh3} &= P_{e3} \cos (90 - \theta + \delta) \\
 &= 0 \text{ k/ft} \times \cos (90 - 90 + 0) \\
 &= 0.00 \text{ k/ft}
 \end{aligned}$$

LAMSON ENGINEERING CORPORATION		Final Page No.:
Project: Bridge No. W-38-003	Job No.:	Preliminary Sheet No.:
Subject: Retaining Wall 2	Prepared by: SL	Date: 5/2023
Detail: Lateral earth pressure	Checked by: JG	Date: 5/2023

Live Load Surcharge (LS) (AASHTO LRFD 3.11.6.4)

$$\text{Equivalent height of soil for , } h_{eq} = 2.000 \text{ ft}$$

$$\begin{aligned} \text{Vertical live load Surcharge on heel, LS} &= 0.125 \text{ kcf} \times 2 \text{ ft} \times 4.5 \text{ ft} \\ &= 1.125 \text{ k / ft} \end{aligned}$$

$$\begin{aligned} \text{Horizontal earth pressure due to live load surcharge } \Delta_p &= K_e \gamma_{\text{soil}} h_{eq} \\ &= 0.398 \times 0.125 \text{ kcf} \times 2 \text{ ft} \\ &= 0.10 \text{ ksf} \end{aligned}$$

$$\begin{aligned} \text{Live load lateral earth pressure, } P_{LS} &= \Delta_p h \\ &= 0.1 \text{ ksf} \times 18.75 \text{ ft} \\ &= 1.87 \text{ k/ft length of wall} \end{aligned}$$

$$\begin{aligned} \text{Vertical component of } P_{LS}, P_{LSV} &= P_{LS} \sin (90 - \alpha + \delta) \\ &= 1.87 \text{ k/ft} \times \sin (90 - 90 + 0) \\ &= 0.00 \text{ k/ft length of wall} \end{aligned}$$





$$\begin{aligned} \text{Horizontal component of } P_{LS}, P_{LSH} &= P_{LS} \cos (90 - \alpha + \delta) \\ &= 1.87 \text{ k/ft} \times \cos (90 - 90 + 0) \\ &= 1.87 \text{ k/ft length of wall} \end{aligned}$$

$$\begin{aligned} \text{Unfactored horizontal load, EH + LSH} &= P_{eh1} + P_{eh2} + P_{eh3} + P_{LSH} \\ &= 8.75 + 0 + 0 + 1.87 \\ &= \underline{10.62 \text{ k/ft length of wall}} \end{aligned}$$

LAMSON ENGINEERING CORPORATION			Final Page No.:	
Project:	Bridge No. W-38-003	Job No.:	Preliminary Sheet No.:	
Subject:	Retaining Wall 2	Prepared by: SL		Date: 5/2023
Detail:	Strength I for Overturning	Checked by: JG		Date: 5/2023

Summary of Factored Loads - Strength IA: 1.25DC + 1.35EH + 1.35EV + 1.75 LS

Vertical Loads and Vertical Moments

Item	Load Factor γ	Vertical load, V (k/ft)	Factored vertical load, V_u (k/ft)	Arm about ⌒ Footing	Factored Moment	
Coping	1.25	0.47	0.59	1.31	0.77	
Stem 	1.25	3.19	3.99	1.27	5.07	
Stem 	1.25	1.19	1.49	0.12	0.17	
Concrete Footing	1.25	3.60	4.50	0.00	0.00	
Vertical Soil 1 	1.35	1.09	1.47	-0.27	-0.39	
Vertical Soil 2 	1.35	6.33	8.55	-2.33	-19.87	
Bridge Railing	1.25	0.09	0.11	1.31	0.15	
P_{v1}	1.35	0.00	0.00	-4.00	0.00	
P_{v2}	1.35	0.00	0.00	-4.00	0.00	
P_{v3}	1.35	0.00	0.00	-4.00	0.00	
P_{LSV}	1.75	0.00	0.00	-4.00	0.00	
LS	1.75	1.13	1.97	-2.33	-4.58	
TOTAL		17.09	22.67		-18.67	ΣM_v

Horizontal Loads and Horizontal Moments

Item	Load Factor γ	Horizontal load H (k/ft)	Factored horizontal load, H_u (k/ft)	Arm about ⌒ Footing	Factored Moment	
P_{h1}	1.35	8.75	11.81	6.25	73.82	
P_{h2}	1.35	0.00	0.00	0.00	0.00	
P_{h3}	1.35	0.00	0.00	0.00	0.00	
P_{LSH}	1.75	1.87	3.27	9.38	30.62	
TOTAL		10.62	15.08		104.44	ΣM_H

LAMSON ENGINEERING CORPORATION				Final Page No.:	
Project: Bridge No. W-38-003, Wilmington		Job No.:		Preliminary Sheet No.:	
Subject: Retaining Wall 2		Prepared by: SL		Date: 5/2023	
Detail: Pile_STR I_VMAX		Checked by: JG		Date: 5/2023	

Pile STR I VMAX

Cross Section = 0.63 ft.²

Number of Pile, n = 26

Length to Wall 63.16 ft

Factored Load at Bottom of Pile Cap Through Centroid of the Pile Group:

No. of Battered Piles = 13

Factored Horizontal Resistance (Front Piles battered 1:4) = 163.53 x 13 ea / 4 = 817.7 kips

Vertical, F_z = 1431.57 kips

F_y = 952.25 - 817.67 = 134.59 kips

F_x = 0.00 kips

M_x = (-18.67+104.44) k-ft/ft x 63.16 ft + 1431.57 k x 0 ft
= 5416.93 k-ft

M_y = 0.00 kips-ft

Pile #	A _p (sf)	X _i (ft.)	Y _i (ft.)	A _p X _i (ft. ³)	A _p Y _i (ft. ³)	dx ² (X _i - X _{C.G.}) ²	dy ² (Y _i - Y _{C.G.}) ²	$\frac{M_x(Y_{C.G.} - Y_i)}{\sum (Y_i - Y_{C.G.})^2}$	$\frac{M_y(X_{C.G.} - X_i)}{\sum (X_i - X_{C.G.})^2}$	F _z / n	Σ F _z (kips)	Shear F _y / n	Shear F _x / n
1	0.63	0.00	-2.50	0.000	-1.576	900.000	6.250	83.34	0.00	55.060	138.40	5.18	0.00
2	0.63	5.00	-2.50	3.151	-1.576	625.000	6.250	83.34	0.00	55.060	138.40	5.18	0.00
3	0.63	10.00	-2.50	6.303	-1.576	400.000	6.250	83.34	0.00	55.060	138.40	5.18	0.00
4	0.63	15.00	-2.50	9.454	-1.576	225.000	6.250	83.34	0.00	55.060	138.40	5.18	0.00
5	0.63	20.00	-2.50	12.606	-1.576	100.000	6.250	83.34	0.00	55.060	138.40	5.18	0.00
6	0.63	25.00	-2.50	15.757	-1.576	25.000	6.250	83.34	0.00	55.060	138.40	5.18	0.00
7	0.63	30.00	-2.50	18.909	-1.576	0.000	6.250	83.34	0.00	55.060	138.40	5.18	0.00
8	0.63	35.00	-2.50	22.060	-1.576	25.000	6.250	83.34	0.00	55.060	138.40	5.18	0.00
9	0.63	40.00	-2.50	25.212	-1.576	100.000	6.250	83.34	0.00	55.060	138.40	5.18	0.00
10	0.63	45.00	-2.50	28.363	-1.576	225.000	6.250	83.34	0.00	55.060	138.40	5.18	0.00
11	0.63	50.00	-2.50	31.515	-1.576	400.000	6.250	83.34	0.00	55.060	138.40	5.18	0.00
12	0.63	55.00	-2.50	34.666	-1.576	625.000	6.250	83.34	0.00	55.060	138.40	5.18	0.00
13	0.63	60.00	-2.50	37.818	-1.576	900.000	6.250	83.34	0.00	55.060	138.40	5.18	0.00
1	0.63	0.00	2.50	0.000	1.576	900.000	6.250	-83.34	0.00	55.060	-28.28	5.18	0.00
2	0.63	5.00	2.50	3.15	1.576	625.00	6.25	-83.34	0.00	55.06	-28.28	5.18	0.00
3	0.63	10.00	2.50	6.303	1.576	400.000	6.250	-83.34	0.00	55.060	-28.28	5.18	0.00
4	0.63	15.00	2.50	9.454	1.576	225.000	6.250	-83.34	0.00	55.060	-28.28	5.18	0.00
5	0.63	20.00	2.50	12.606	1.576	100.000	6.250	-83.34	0.00	55.060	-28.28	5.18	0.00
6	0.63	25.00	2.50	15.757	1.576	25.000	6.250	-83.34	0.00	55.060	-28.28	5.18	0.00
7	0.63	30.00	2.50	18.909	1.576	0.000	6.250	-83.34	0.00	55.060	-28.28	5.18	0.00
8	0.63	35.00	2.50	22.060	1.576	25.000	6.250	-83.34	0.00	55.060	-28.28	5.18	0.00
9	0.63	40.00	2.50	25.212	1.576	100.000	6.250	-83.34	0.00	55.060	-28.28	5.18	0.00
10	0.63	45.00	2.50	28.363	1.576	225.000	6.250	-83.34	0.00	55.060	-28.28	5.18	0.00
11	0.63	50.00	2.50	31.515	1.576	400.000	6.250	-83.34	0.00	55.060	-28.28	5.18	0.00
12	0.63	55.00	2.50	34.666	1.576	625.000	6.250	-83.34	0.00	55.060	-28.28	5.18	0.00
13	0.63	60.00	2.50	37.818	1.576	900.000	6.250	-83.34	0.00	55.060	-28.28	5.18	0.00
26	16.39			491.63	0.00						138.40 -28.28	5.18 5.18	

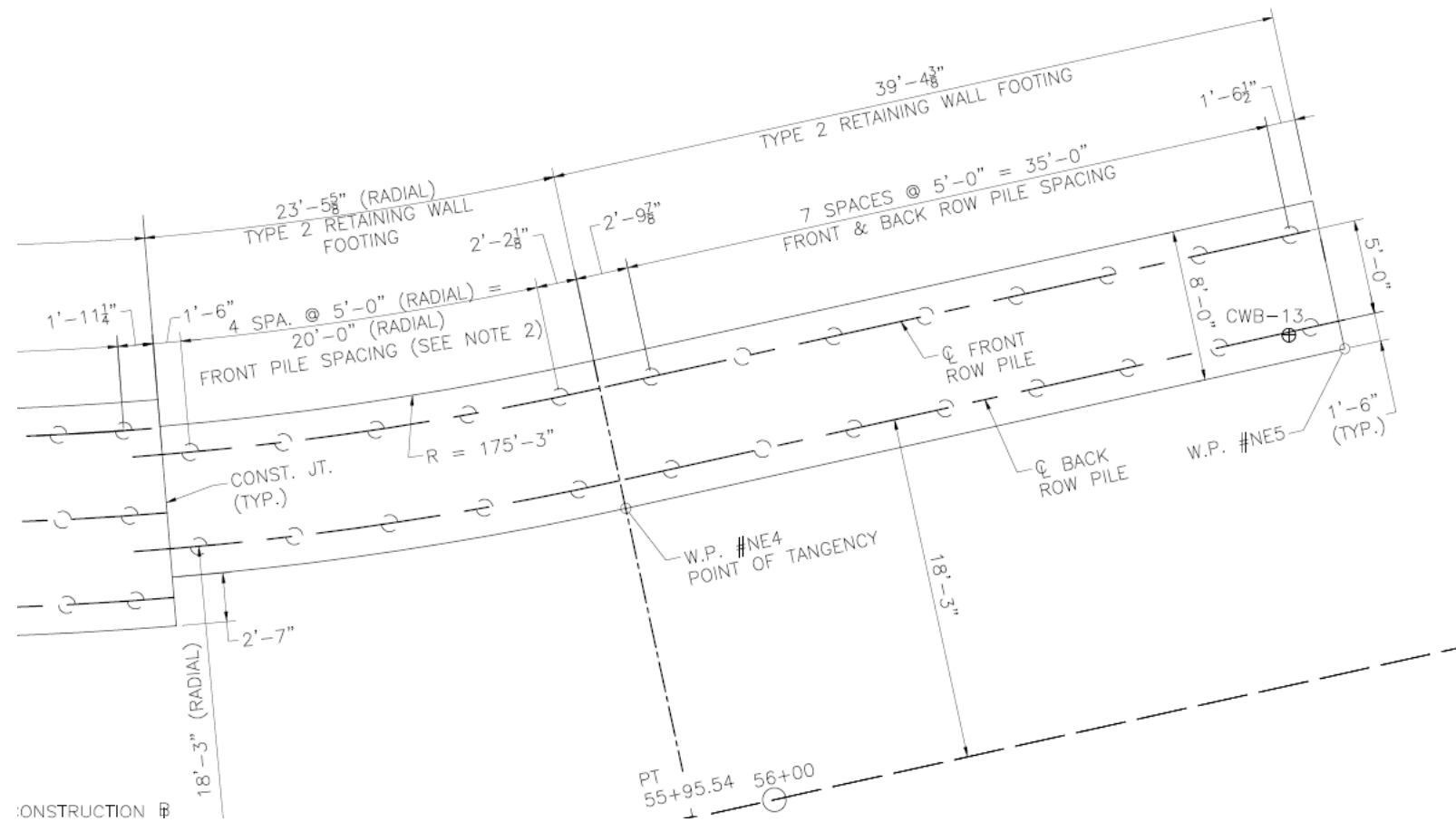
X_{C.G.} = ΣA_p X_i / ΣA_p = 491.63 / 16.39 = 30.000 ft. Y_{C.G.} = ΣA_p Y_i / ΣA_p = 0.00 / 16.39 = 0.000 ft. from Pile Cap Center

Σ(X_i-X_{C.G.})² = 9100 ft.² Σ(Y_i-Y_{C.G.})² = 162.50 ft.²

Resultant Shear on Single Pile = (5.18² + 0.00²)^{0.5} = 5.18 kips

LAMSON ENGINEERING CORPORATION		Final Page No.:
Project: Bridge No. W-38-003, Wilmington	Job No.:	Preliminary Sheet No.:
Subject: Retaining Wall 2	Prepared by: SL	Date: 5/2023
Detail: Pile_STR I_VMAX	Checked by: JG	Date: 5/2023

Pile STR I VMAX



Pile Layout

LAMSON ENGINEERING CORPORATION			Final Page No.:	
Project: Bridge No. W-38-003	Job No.:		Preliminary Sheet No.:	
Subject: Retaining Wall 2	Prepared by: SL		Date: 5/2023	
Detail: Strength I for Sliding and Eccentricity	Checked by: JG		Date: 5/2023	

Summary of Factored Loads - Strength IB: 0.90DC + 1.35EH + 1.0EV + 1.75 LS

Vertical Loads and Vertical Moments

Item	Load Factor γ	Vertical load, V (k/ft)	Factored vertical load, V_u (k/ft)	Arm about CL Footing	Factored Moment	
Coping	0.90	0.47	0.43	1.31	0.56	
Stem	0.90	3.19	2.87	1.27	3.65	
Stem	0.90	1.19	1.07	0.12	0.12	
Concrete Footing	0.90	3.60	3.24	0.00	0.00	
Vertical Soil 1	1.00	1.09	1.09	-0.27	-0.29	
Vertical Soil 2	1.00	6.33	6.33	-2.33	-14.72	
Bridge Railing	0.90	0.09	0.08	1.31	0.11	
P_{v1}	1.35	0.00	0.00	-4.00	0.00	
P_{v2}	1.35	0.00	0.00	-4.00	0.00	
P_{v3}	1.35	0.00	0.00	-4.00	0.00	
P_{LSV}	1.75	0.00	0.00	-4.00	0.00	
LS	1.75	0.00	0.00	-2.33	0.00	
TOTAL		15.97	15.11		-10.57	ΣM_v

Horizontal Loads and Horizontal Moments

Item	Load Factor γ	Horizontal load H (k/ft)	Factored horizontal load, H_u (k/ft)	Arm about CL Footing	Factored Moment	
P_{h1}	1.35	8.75	11.81	6.25	73.82	
P_{h2}	1.35	0.00	0.00	0.00	0.00	
P_{h3}	1.35	0.00	0.00	0.00	0.00	
P_{LSH}	1.75	1.87	3.27	9.38	30.62	
TOTAL		10.62	15.08		104.44	ΣM_H

LAMSON ENGINEERING CORPORATION				Final Page No.:	
Project: Bridge No. W-38-003, Wilmington		Job No.:		Preliminary Sheet No.:	
Subject: Retaining Wall 2		Prepared by: SL		Date: 5/2023	
Detail: Pile_STR I_VMIN		Checked by: JG		Date: 5/2023	

Pile STR I VMIN

Cross Section = 0.63 ft.²

Number of Pile, n = 26

Length between Expansion Joints = 63.16 ft

Factored Load at Bottom of Pile Cap Through Centroid of the Pile Group:

No. of Battered Piles = 13

Factored Horizontal Resistance (Front Piles battered 1:4) = 163.53 x 13 ea / 4 = 817.7 kips

Vertical, F_z = 954.32 kips

F_y = 952.25 - 817.67 = 134.59 kips

F_x = 0.00 kips

M_x = (-10.57+104.44) k-ft/ft x 63.16 ft + 954.32 k x 0 ft
= 5928.77 k-ft

M_y = 0.00 kips-ft

Pile #	A _p (sf)	X _i (ft.)	Y _i (ft.)	A _p X _i (ft. ³)	A _p Y _i (ft. ³)	dx ² (X _i - X _{C.G.}) ²	dy ² (Y _i - Y _{C.G.}) ²	$\frac{M_x(Y_{C.G.} - Y_i)}{\sum (Y_i - Y_{C.G.})^2}$	$\frac{M_y(X_{C.G.} - X_i)}{\sum (X_i - X_{C.G.})^2}$	F _z / n	Σ F _z (kips)	Shear F _y / n	Shear F _x / n
1	0.63	0.00	-2.50	0.000	-1.576	900.000	6.250	91.21	0.00	36.705	127.92	5.18	0.00
2	0.63	5.00	-2.50	3.151	-1.576	625.000	6.250	91.21	0.00	36.705	127.92	5.18	0.00
3	0.63	10.00	-2.50	6.303	-1.576	400.000	6.250	91.21	0.00	36.705	127.92	5.18	0.00
4	0.63	15.00	-2.50	9.454	-1.576	225.000	6.250	91.21	0.00	36.705	127.92	5.18	0.00
5	0.63	20.00	-2.50	12.606	-1.576	100.000	6.250	91.21	0.00	36.705	127.92	5.18	0.00
6	0.63	25.00	-2.50	15.757	-1.576	25.000	6.250	91.21	0.00	36.705	127.92	5.18	0.00
7	0.63	30.00	-2.50	18.909	-1.576	0.000	6.250	91.21	0.00	36.705	127.92	5.18	0.00
8	0.63	35.00	-2.50	22.060	-1.576	25.000	6.250	91.21	0.00	36.705	127.92	5.18	0.00
9	0.63	40.00	-2.50	25.212	-1.576	100.000	6.250	91.21	0.00	36.705	127.92	5.18	0.00
10	0.63	45.00	-2.50	28.363	-1.576	225.000	6.250	91.21	0.00	36.705	127.92	5.18	0.00
11	0.63	50.00	-2.50	31.515	-1.576	400.000	6.250	91.21	0.00	36.705	127.92	5.18	0.00
12	0.63	55.00	-2.50	34.666	-1.576	625.000	6.250	91.21	0.00	36.705	127.92	5.18	0.00
13	0.63	60.00	-2.50	37.818	-1.576	900.000	6.250	91.21	0.00	36.705	127.92	5.18	0.00
1	0.63	0.00	2.50	0.000	1.576	900.000	6.250	-91.21	0.00	36.705	-54.51	5.18	0.00
2	0.63	5.00	2.50	3.151	1.576	625.000	6.250	-91.21	0.00	36.705	-54.51	5.18	0.00
3	0.63	10.00	2.50	6.30	1.58	400.00	6.25	-91.21	0.00	36.70	-54.51	5.18	0.00
4	0.63	15.00	2.50	9.45	1.58	225.00	6.25	-91.21	0.00	36.70	-54.51	5.18	0.00
5	0.63	20.00	2.50	12.61	1.58	100.00	6.25	-91.21	0.00	36.70	-54.51	5.18	0.00
6	0.63	25.00	2.50	15.76	1.58	25.00	6.25	-91.21	0.00	36.70	-54.51	5.18	0.00
7	0.63	30.00	2.50	18.91	1.58	0.00	6.25	-91.21	0.00	36.70	-54.51	5.18	0.00
8	0.63	35.00	2.50	22.06	1.58	25.00	6.25	-91.21	0.00	36.70	-54.51	5.18	0.00
9	0.63	40.00	2.50	25.21	1.58	100.00	6.25	-91.21	0.00	36.70	-54.51	5.18	0.00
10	0.63	45.00	2.50	28.36	1.58	225.00	6.25	-91.21	0.00	36.70	-54.51	5.18	0.00
11	0.63	50.00	2.50	31.51	1.58	400.00	6.25	-91.21	0.00	36.70	-54.51	5.18	0.00
12	0.63	55.00	2.50	34.67	1.58	625.00	6.25	-91.21	0.00	36.70	-54.51	5.18	0.00
13	0.63	60.00	2.50	37.82	1.58	900.00	6.25	-91.21	0.00	36.70	-54.51	5.18	0.00
26	16.39			491.63	0.00						127.92 -54.51	5.18 5.18	

X_{C.G.} = ΣA_p X_i / ΣA_p = 491.63 / 16.39 = 30.000 ft. Y_{C.G.} = ΣA_p Y_i / ΣA_p = 0.00 / 16.39 = 0.000 ft.

Σ(X_i-X_{C.G.})² = 9100 ft.² Σ(Y_i-Y_{C.G.})² = 162.50 ft.²

Resultant Shear on Single Pile = (5.18² + 0.00²)^{0.5} = 5.18 kips

LAMSON ENGINEERING CORPORATION		Final Page No.:	
Project: Bridge No. W-38-003	Job No.:	Preliminary Sheet No.:	
Subject: Retaining Wall 2	Prepared by: SL		Date: 5/2023
Detail: Service I for Settlement	Checked by: JG		Date: 5/2023

Summary of Factored Loads - Service I: 1.0DC + 1.0EH + 1.0EV

Vertical Loads and Vertical Moments

Item	Load Factor γ	Vertical load, V (k/ft)	Factored vertical load, V_u (k/ft)	Arm about CL Footing	Factored Moment
Coping	1.00	0.47	0.47	1.31	0.62
Stem	1.00	3.19	3.19	1.27	4.06
Stem	1.00	1.19	1.19	0.12	0.14
Concrete Footing	1.00	3.60	3.60	0.00	0.00
Vertical Soil 1	1.00	1.09	1.09	-0.27	-0.29
Vertical Soil 2	1.00	6.33	6.33	-2.33	-14.72
Bridge Railing	1.00	0.09	0.09	1.31	0.12
P_{v1}	1.00	0.00	0.00	-4.00	0.00
P_{v2}	1.00	0.00	0.00	-4.00	0.00
P_{v3}	1.00	0.00	0.00	-4.00	0.00
P_{LSV}	1.00	0.00	0.00	-4.00	0.00
LS	1.00	1.13	1.13	-2.33	-2.62
TOTAL		17.09	17.09		-12.69

ΣM_v

Horizontal Loads and Horizontal Moments

Item	Load Factor γ	Horizontal load H (k/ft)	Factored horizontal load, H_u (k/ft)	Arm about CL Footing	Factored Moment
P_{h1}	1.00	8.75	8.75	6.25	54.68
P_{h2}	1.00	0.00	0.00	0.00	0.00
P_{h3}	1.00	0.00	0.00	0.00	0.00
P_{LSH}	1.00	1.87	1.87	9.38	17.50
TOTAL		10.62	10.62		72.18

ΣM_H

LAMSON ENGINEERING CORPORATION		Final Page No.:	
Project: Bridge No. W-38-003, Wilmington	Job No.:	Preliminary Sheet No.:	
Subject: Retaining Wall 2	Prepared by: SL	Date:	5/2023
Detail: Pile_SERVICE I	Checked by: JG	Date:	5/2023

Pile_SERVICE I

Cross Section = 0.63 ft.²

Number of Pile, n = 26

Length to Expansion Joint = 63.16 ft

Factored Load at Bottom of Pile Cap Through Centroid of the Pile Group:

No. of Battered Piles = 13

Factored Horizontal Resistance (Front Piles battered 1:4) = 163.53 x 13 ea / 4 = 817.7 kips

Vertical, F_z = 1079.36 kips

F_y = 670.45 - 817.67 = 0.00 kips

F_x = 0.00 kips

M_x = (-12.69+72.18) k-ft/ft x 63.16 ft + 1079.36 k x 0 ft
= 3757.13 k-ft

M_y = 0.00 kips-ft

Pile #	A _p (sf)	X _i (ft.)	Y _i (ft.)	A _p X _i (ft. ³)	A _p Y _i (ft. ³)	dx ² (X _i - X _{C.G.}) ²	dy ² (Y _i - Y _{C.G.}) ²	$\frac{M_x(Y_{C.G.} - Y_i)}{\sum (Y_i - Y_{C.G.})^2}$	$\frac{M_y(X_{C.G.} - X_i)}{\sum (X_i - X_{C.G.})^2}$	F _z / n	Σ F _z (kips)	Shear F _y / n	Shear F _x / n
1	0.63	0.00	-2.50	0.000	-1.576	900.000	6.250	57.80	0.00	41.514	99.32	0.00	0.00
2	0.63	5.00	-2.50	3.151	-1.576	625.000	6.250	57.80	0.00	41.514	99.32	0.00	0.00
3	0.63	10.00	-2.50	6.303	-1.576	400.000	6.250	57.80	0.00	41.514	99.32	0.00	0.00
4	0.63	15.00	-2.50	9.454	-1.576	225.000	6.250	57.80	0.00	41.514	99.32	0.00	0.00
5	0.63	20.00	-2.50	12.606	-1.576	100.000	6.250	57.80	0.00	41.514	99.32	0.00	0.00
6	0.63	25.00	-2.50	15.757	-1.576	25.000	6.250	57.80	0.00	41.514	99.32	0.00	0.00
7	0.63	30.00	-2.50	18.909	-1.576	0.000	6.250	57.80	0.00	41.514	99.32	0.00	0.00
8	0.63	35.00	-2.50	22.060	-1.576	25.000	6.250	57.80	0.00	41.514	99.32	0.00	0.00
9	0.63	40.00	-2.50	25.212	-1.576	100.000	6.250	57.80	0.00	41.514	99.32	0.00	0.00
10	0.63	45.00	-2.50	28.363	-1.576	225.000	6.250	57.80	0.00	41.514	99.32	0.00	0.00
11	0.63	50.00	-2.50	31.515	-1.576	400.000	6.250	57.80	0.00	41.514	99.32	0.00	0.00
12	0.63	55.00	-2.50	34.666	-1.576	625.000	6.250	57.80	0.00	41.514	99.32	0.00	0.00
13	0.63	60.00	-2.50	37.818	-1.576	900.000	6.250	57.80	0.00	41.514	99.32	0.00	0.00
1	0.63	0.00	2.50	0.000	1.576	900.000	6.250	-57.80	0.00	41.514	-16.29	0.00	0.00
2	0.63	5.00	2.50	3.151	1.576	625.000	6.250	-57.80	0.00	41.514	-16.29	0.00	0.00
3	0.63	10.00	2.50	6.303	1.576	400.000	6.250	-57.80	0.00	41.514	-16.29	0.00	0.00
4	0.63	15.00	2.50	9.454	1.576	225.000	6.250	-57.80	0.00	41.514	-16.29	0.00	0.00
5	0.63	20.00	2.50	12.606	1.576	100.000	6.250	-57.80	0.00	41.514	-16.29	0.00	0.00
6	0.63	25.00	2.50	15.757	1.576	25.000	6.250	-57.80	0.00	41.514	-16.29	0.00	0.00
7	0.63	30.00	2.50	18.909	1.576	0.000	6.250	-57.80	0.00	41.514	-16.29	0.00	0.00
8	0.63	35.00	2.50	22.060	1.576	25.000	6.250	-57.80	0.00	41.514	-16.29	0.00	0.00
9	0.63	40.00	2.50	25.212	1.576	100.000	6.250	-57.80	0.00	41.514	-16.29	0.00	0.00
10	0.63	45.00	2.50	28.363	1.576	225.000	6.250	-57.80	0.00	41.514	-16.29	0.00	0.00
11	0.63	50.00	2.50	31.515	1.576	400.000	6.250	-57.80	0.00	41.514	-16.29	0.00	0.00
12	0.63	55.00	2.50	34.666	1.576	625.000	6.250	-57.80	0.00	41.514	-16.29	0.00	0.00
13	0.63	60.00	2.50	37.818	1.576	900.000	6.250	-57.80	0.00	41.514	-16.29	0.00	0.00
26	16.39			491.63	0.00						99.32	0.00	
											-16.29	0.00	

X_{C.G.} = ΣA_p X_i / ΣA_p = 491.63 / 16.39 = 30.000 ft.

Y_{C.G.} = ΣA_p Y_i / ΣA_p = 0.00 / 16.39 = 0.000 ft.

Σ(X_i-X_{C.G.})² = 9100 ft.² Σ(Y_i-Y_{C.G.})² = 162.50 ft.²

Resultant Shear on Single Pile = (0.00² + 0.00²)^{0.5} = 0.00 kips

LAMSON ENGINEERING CORPORATION		Final Page No:	
Project:	Bridge No. W-38-003, Wilmington	Job No:	Preliminary Sheet No:
Subject:	Wingwall Type 2 - 10.75 Dia. Micropile	Prepared by: SL	Date: 12/2022
Detail:	Micropile Vertical Resistance	Checked by: JG	Date: 12/2022

Axial Compression Resistance

Based on Boring BB-1 $O.D. = 10.75$ in. $t_{wall} = 0.595$ in.

$$R_R = \text{Factored Resistance of a micropile}$$

$$= \phi R_n = \phi_{qp} R_p + \phi_{qs} R_s$$

in which:

$$R_p = q_p A_p$$

$$R_s = q_s A_s$$

where:

$$R_p = \text{nominal tip resistance}$$

(Per AASHTO C10.9.3.5.1, tip resistance is neglected for conservative)

$$R_s = \text{nominal grout to ground bond resistance}$$

$$\phi_{qp} = \text{resistance factor for tip resistance}$$

$$= 0.50 \quad (\text{AASHTO 10.5.5.2.5-1})$$

$$\phi_{qs} = \text{resistance factor for grout-to-ground resistance}$$

$$= 0.55 \quad (\text{AASHTO 10.5.5.2.5-1})$$

$$d_p = \text{diameter of micropile tip}$$

$$= 9.56 \text{ in.}$$

$$A_p = \text{area of micropile tip} = \pi D^2/4$$

$$= 71.78 \text{ in.}^2 = 0.50 \text{ ft}^2$$

$$R_s = \pi d_b \alpha_b L_b$$

in which:

$$d_b = \text{diameter of micropile drill hole through bonded length}$$

$$= 9.56 \text{ in.} = 0.80 \text{ ft}$$

$$\alpha_b = \text{nominal micropile grout-to-ground bond strength}$$

$$= 21.6 \text{ ksf for Type A Diorite}$$

(AASHTO Table C10.9.3.5.2 - 1)

LAMSON ENGINEERING CORPORATION		Final Page No:	
Project:	Bridge No. W-38-003, Wilmington	Job No:	Preliminary Sheet No:
Subject:	Wingwall Type 2 - 10.75 Dia. Micropile	Prepared by: SL	Date: 12/2022
Detail:	Micropile Vertical Resistance	Checked by: JG	Date: 12/2022

$$\begin{aligned}
 L_b &= \text{micropile bonded length} \\
 &= 5.5 \text{ ft into Intact Bedrock}
 \end{aligned}$$

$$\begin{aligned}
 \phi_{qs} R_s &= 0.55 \times 3.141 \times 0.8 \times [21.6 \times 5.5] \\
 &= 163.5 \text{ kips}
 \end{aligned}$$

$$R_n = 163.53 / 0.55 = \underline{297 \text{ kips}}$$

$$R_R = \underline{164 \text{ kips}}$$

Uplift Resistance

$$\text{Uplift Resistance} = 50 \% \text{ of the compression resistance}$$

$$= 0.5 \times 163.5 = \underline{82 \text{ kips}}$$

$$\begin{aligned}
 \phi_{up} &= \text{resistance factor} \\
 &= 0.55
 \end{aligned}$$

$$\text{Nominal Resistance} = 81.8 / 0.55 = \underline{149 \text{ kips}}$$

Structural Resistance

Axial Compression Resistance

$$\begin{aligned}
 R_C &= \text{Factored Structural Resistance of a micropile} \\
 &= \phi_c R_n
 \end{aligned}$$

in which:

$$\begin{aligned}
 \phi_c &= \text{resistance factor for tip resistance} \\
 &= 0.75 \quad (\text{AASHTO 10.5.5.2.5-2})
 \end{aligned}$$

$$R_n = \text{Nominal axial compression resistance}$$

• For the cased length

$$F_y = 52 \text{ ksi}$$

$$f_y = 60 \text{ ksi} \quad (\text{Reinforcing Bar Grade 60})$$

LAMSON ENGINEERING CORPORATION			Final Page No:	
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Detail:	Micropile Vertical Resistance	Checked by:	JG	Date: 12/2022

$$R_n = 0.85 [0.85 f'_c A_g + f_y (A_b + A'_c)]$$

where:

$$f'_c = \text{specified compressive strength of micropile grout at 28 days}$$

$$= 5.0 \text{ ksi}$$

$$f_y = \text{specified minimum yield strength of reinforcement bar or steel casing, or stress in steel reinforcement bar or casing at a strain of 0.003, whichever is less}$$

$$\text{Min. } (F_y, f_y) = 52.0 \text{ ksi}$$

$$d_b = 1.69 \text{ in. } \#14 \text{ threaded bar}$$

$$A_b = \text{cross-section area of steel reinforcing bar}$$

$$= 2.25 \text{ in.}^2$$

$$A_c = \text{cross-section area of steel casing}$$

$$= 18.98 \text{ in.}^2$$

$$A'_c = \text{cross-section area of steel casing with 1/16" section loss on outside of the casing}$$

$$= 16.9 \text{ in.}^2 \quad \text{Section loss} = 0.063 \text{ in.}$$

$$A_g = \text{cross-section area of grout within micropile}$$

$$= A_{ID} - A_b = 71.78 - 2.25$$

$$= 69.53 \text{ in.}^2$$

$$R_n = 0.85 \times [0.85 \times 5 \times 69.53 + 52 \times (2.25 + 16.88)]$$

$$= 1096.9 \text{ kips}$$

$$R_{CC} = 0.75 \times 1096.9 = \underline{823 \text{ kips}}$$

• For the uncased length

$$R_n = 0.85 [0.85 f'_c A_g + f_y A_b]$$

$$f_y = \text{specified minimum yield strength of reinforcement bar or stress in steel reinforcement bar at a strain of 0.003, whichever is less}$$

$$= 60.0 \text{ ksi}$$

$$= 60 \text{ ksi}$$

LAMSON ENGINEERING CORPORATION			Final Page No:	
Project:	Bridge No. W-38-003, Wilmington	Job No:	Preliminary Sheet No:	
Subject:	Wingwall Type 2 - 10.75 Dia. Micropile	Prepared by:	SL	Date: 12/2022
Detail:	Micropile Vertical Resistance	Checked by:	JG	Date: 12/2022

$$\begin{aligned}
 R_n &= 0.85 \times [0.85 \times 5 \times 69.53 + 60 \times 2.25] \\
 &= 366.0 \quad \text{kips}
 \end{aligned}$$

$$R_{CU} = 0.75 \times 366 = \underline{274 \text{ kips}}$$

Axial Tension Resistance

$$\begin{aligned}
 R_T &= \text{factored Structural Resistance of a micropile} \\
 &= \phi_T R_n
 \end{aligned}$$

in which:

$$\begin{aligned}
 \phi_T &= \text{resistance factor for tip resistance} \\
 &= 0.80 \quad \text{(AASHTO 10.5.5.2.5-2)}
 \end{aligned}$$

$$R_n = \text{nominal axial tension resistance}$$

• For the cased length

$$\begin{aligned}
 R_n &= f_y (A_b + A'_c)] \\
 &= 52 \times (2.25 + 16.88) = 995.0 \text{ kips}
 \end{aligned}$$

$$R_{TC} = 0.8 \times 995 = \underline{796 \text{ kips}}$$

• For the uncased length

$$\begin{aligned}
 R_n &= f_y A_b \\
 &= 60 \times 2.25 = 135.1 \text{ kips}
 \end{aligned}$$

$$R_{TU} = 0.8 \times 135.1 = \underline{108 \text{ kips}}$$

LAMSON ENGINEERING CORPORATION		Final Page No:	
Project:	Bridge No. W-38-003, Wilmington	Job No:	Preliminary Sheet No:
Subject:	Wingwall Micropile Foundation	Prepared by: SL	Date: 12/2022
Detail:	Lpile Analysis	Checked by: JG	Date: 12/2022

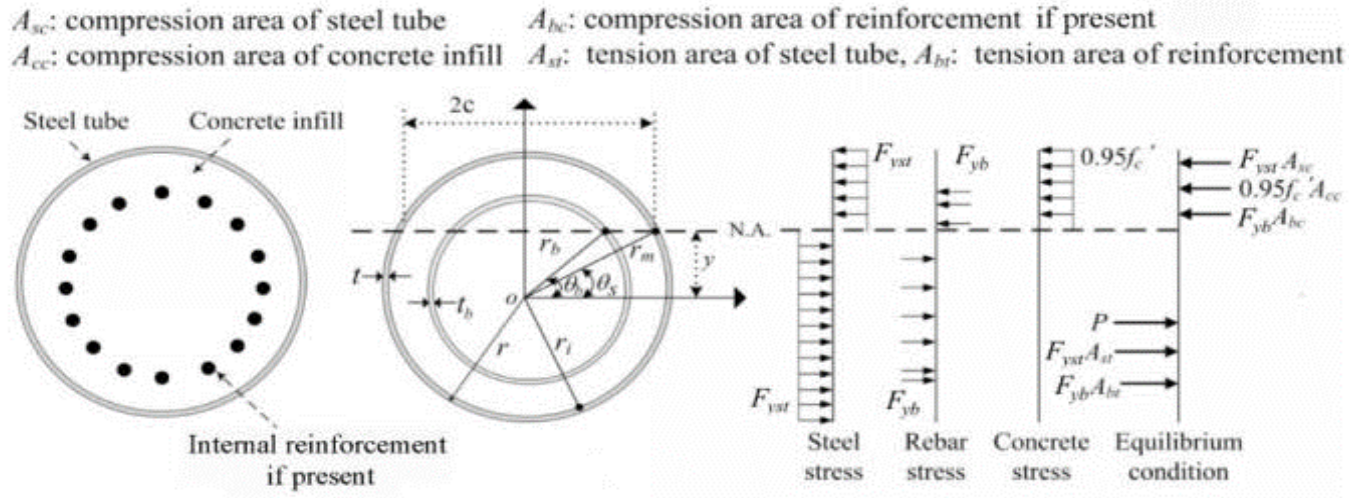


Figure C6.12.2.3.3-1—PSDM Model

$$\begin{aligned}
 P_n = & F_{yst} t r_m \left[(\pi - 2\theta_s) - (\pi + 2\theta_s) \right] \\
 & + t_b r_b \left[F_{yb} (\pi - 2\theta_b) - (F_{yb} - 0.95f'_c) (\pi + 2\theta_b) \right] \\
 & + \frac{0.95f'_c}{2} \left[(\pi - 2\theta_s) r_i^2 - 2yc \right]
 \end{aligned}
 \tag{C6.12.2.3.3-1}$$

$$\begin{aligned}
 M_n = & 0.95f'_c c \left[(r_i^2 - y^2) - \frac{c^2}{3} \right] + 4F_{yst} t c \frac{r_m^2}{r_i} + 4F_{yb} t_b c_b r_b
 \end{aligned}
 \tag{C6.12.2.3.3-2}$$

in which:

$$r_m = r - \frac{t}{2}
 \tag{C6.12.2.3.3-3}$$

$$\theta_s = \sin^{-1} \left(\frac{y}{r_m} \right)
 \tag{C6.12.2.3.3-4}$$

$$\theta_b = \sin^{-1} \left(\frac{y}{r_b} \right)
 \tag{C6.12.2.3.3-5}$$

$$c = r_i \cos \theta_s
 \tag{C6.12.2.3.3-6}$$

$$c_b = r_b \cos \theta_b
 \tag{C6.12.2.3.3-7}$$

$$t_b = \frac{nA_b}{2\pi r_b}
 \tag{C6.12.2.3.3-8}$$

LAMSON ENGINEERING CORPORATION			Final Page No:	
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Detail:	Lpile Analysis	Checked by: JG	Date:	12/2022

Yield Strength, $F_{yst} = 52.00$ ksi
 Strength of Concrete, $f'_c = 5.00$ ksi
 Resistance factor for CFST in compression, $\phi_c = 0.90$ (AASHTO 6.5.4.2)
 Yield Strength, $F_{yb} = 60.00$ ksi
 (AASHTO 6.9.6.2 Limitations) $D/t = 20.0 < 0.15 E / F_{yst} = 83.7$ **OK**
 Concrete shall be greater than 3 ksi or $0.075 F_{yst} = 3.9$ ksi < 5.00 ksi **OK**

$A_s = 2.25$ in² Cover = 3.934 in.
 $r = 5.313$ in. $t = 0.5325$ in.
 $r_m = 5.046$ in.
 $r_i = 4.780$ in.
 $r_b = 0.000$ in. Internal reinforcement is not considered.
 Number of reinforcing bars, $n = 1.0$
 $t_b = n A_s / (2 \pi r_b) = 0$ in.

Strength I

Factored Moment = 22.8 k-ft from Lpile
 Factored Axial Load = 138.4 k from Lpile

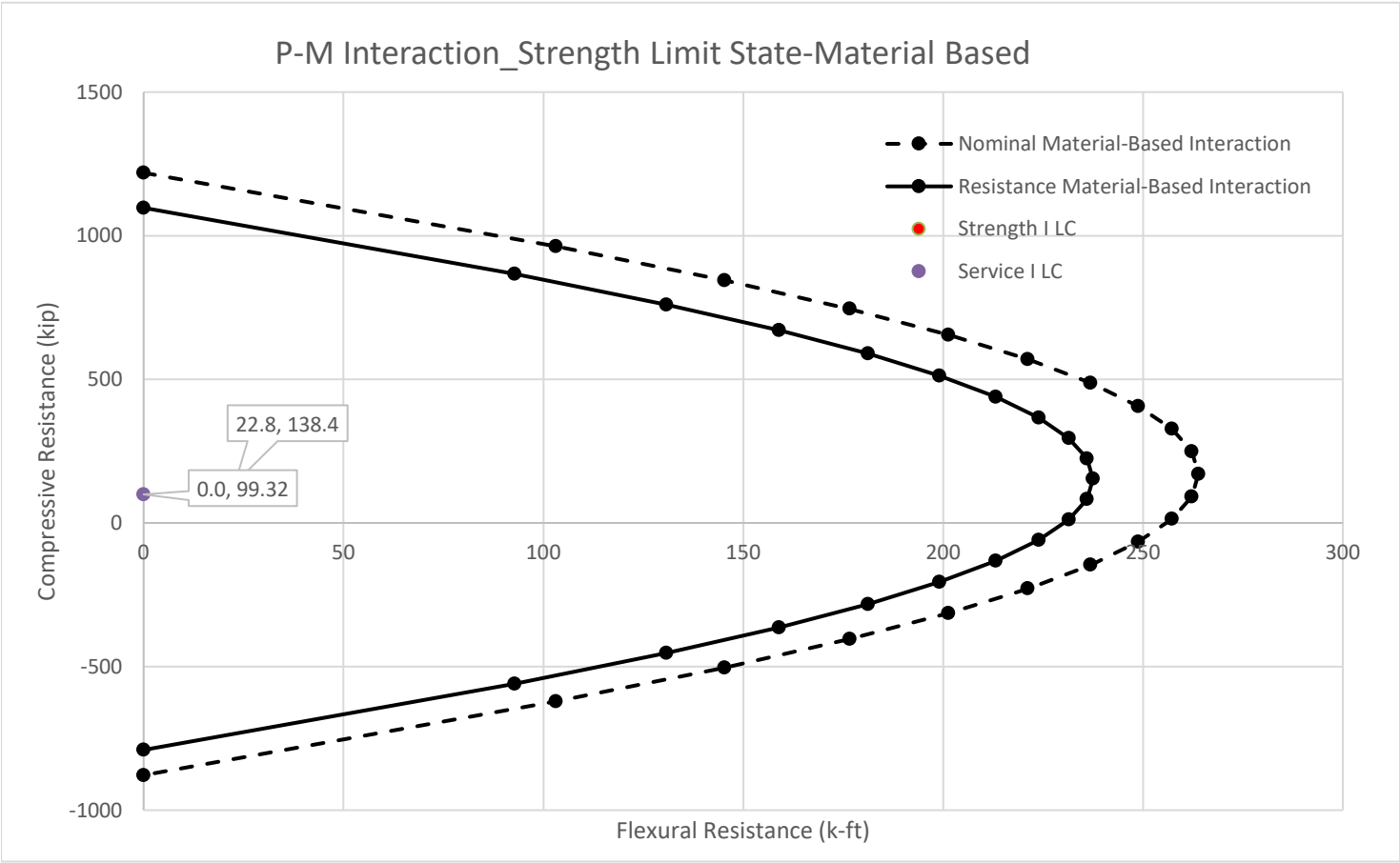
Service I

Factored Moment = 0.0 k-ft from Lpile
 Factored Axial Load = 99.32 k from Lpile

Composite Concrete-Filled Steel Tubes (CFSTs) (AASHTO LRFD 6.12.2.3.3)

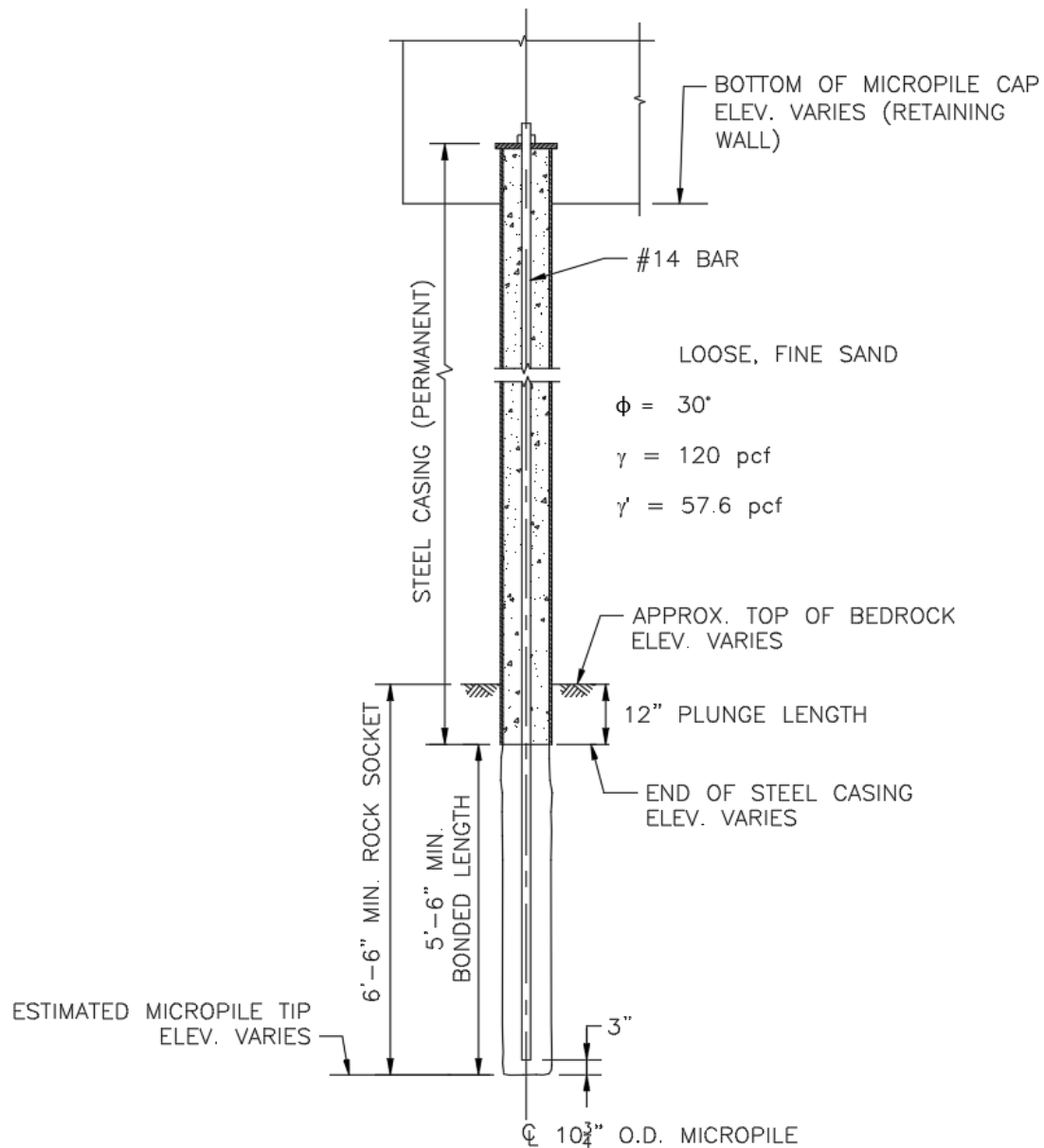
y (in.)	θ_s (rad)	θ_b (rad)	$c = r_i \cos \theta_b$	$c_b = r_b \cos \theta_b$	$\pi - 2 \theta_s$	$\pi + 2 \theta_s$	M_n (kips-ft)	P_n (kips)	$\phi_c M_n$ (kips-ft)	$\phi_c P_n$ (kips)
-5.05	-1.57	-1.57	0.00	0.00	6.28	0.00	0.00	1218.91	0.00	1097.02
-4.54	-1.12	-1.57	2.08	0.00	5.38	0.90	103.09	962.82	92.78	866.54
-4.04	-0.93	-1.57	2.87	0.00	5.00	1.29	145.35	844.40	130.81	759.96
-3.53	-0.78	-1.57	3.41	0.00	4.69	1.59	176.62	745.30	158.95	670.77
-3.03	-0.64	-1.57	3.82	0.00	4.43	1.85	201.36	654.98	181.23	589.48
-2.52	-0.52	-1.57	4.14	0.00	4.19	2.09	221.20	569.57	199.08	512.61
-2.02	-0.41	-1.57	4.38	0.00	3.96	2.32	236.88	487.15	213.19	438.44
-1.51	-0.30	-1.57	4.56	0.00	3.75	2.53	248.81	406.64	223.93	365.97
-1.01	-0.20	-1.57	4.68	0.00	3.54	2.74	257.20	327.33	231.48	294.59
-0.50	-0.10	-1.57	4.76	0.00	3.34	2.94	262.20	248.74	235.98	223.86
0.00	0.00	1.57	4.78	0.00	3.14	3.14	263.86	170.48	237.47	153.43
0.50	0.10	1.57	4.76	0.00	2.94	3.34	262.20	92.22	235.98	83.00
1.01	0.20	1.57	4.68	0.00	2.74	3.54	257.20	13.63	231.48	12.27
1.51	0.30	1.57	4.56	0.00	2.53	3.75	248.81	-65.68	223.93	-59.11
2.02	0.41	1.57	4.38	0.00	2.32	3.96	236.88	-146.19	213.19	-131.57
2.52	0.52	1.57	4.14	0.00	2.09	4.19	221.20	-228.61	199.08	-205.75
3.03	0.64	1.57	3.82	0.00	1.85	4.43	201.36	-314.02	181.23	-282.62
3.53	0.78	1.57	3.41	0.00	1.59	4.69	176.62	-404.34	158.95	-363.90
4.04	0.93	1.57	2.87	0.00	1.29	5.00	145.35	-503.44	130.81	-453.10
4.54	1.12	1.57	2.08	0.00	0.90	5.38	103.09	-621.86	92.78	-559.68
5.05	1.57	1.57	0.00	0.00	0.00	6.28	0.00	-877.95	0.00	-790.16

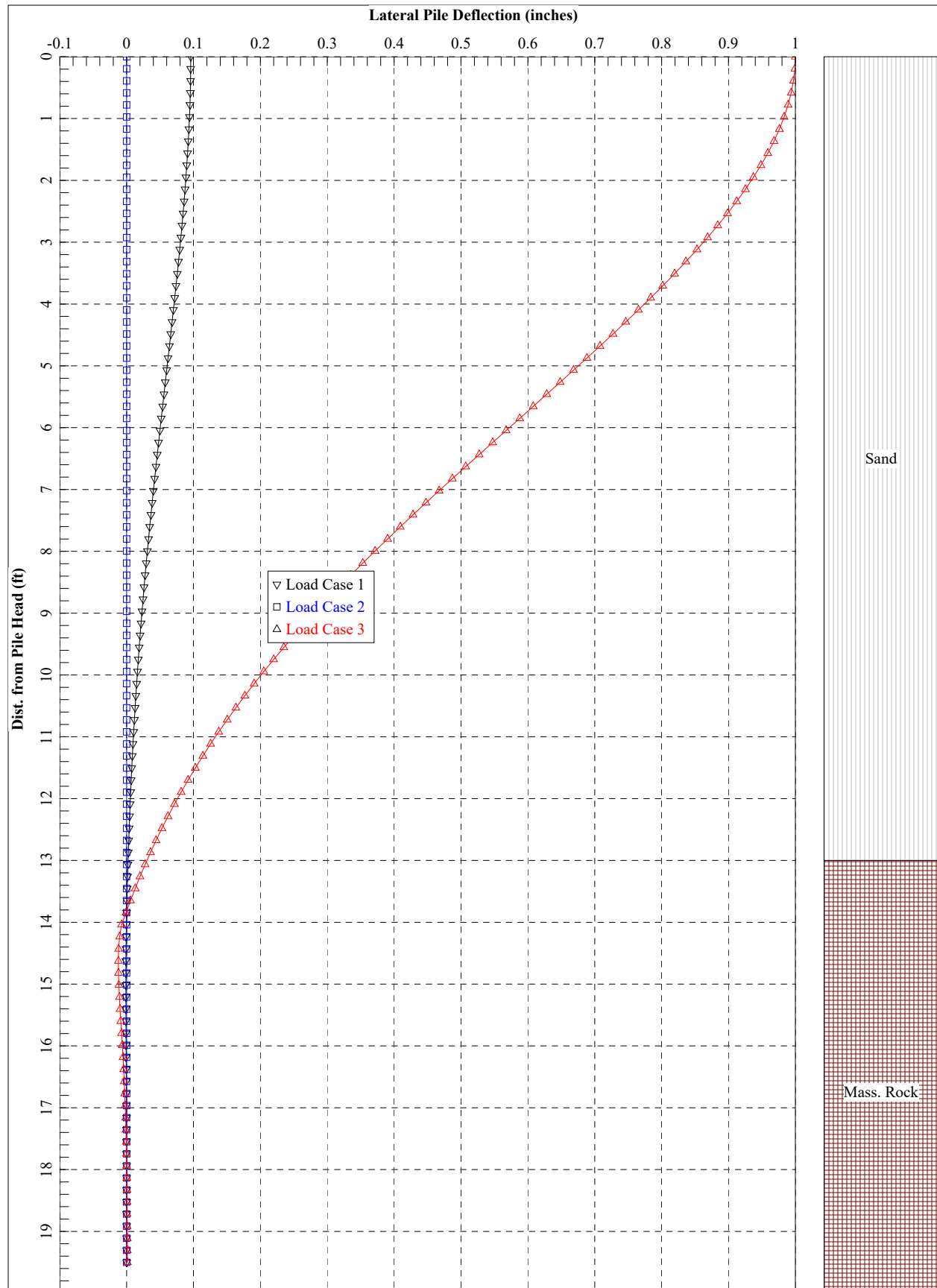
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Project:	Bridge No. W-38-003, Wilmington	Job No:	Preliminary Sheet No:
Subject:	Wingwall Micropile Foundation	Prepared by: SL	Date: 12/2022
Detail:	Lpile Analysis	Checked by: JG	Date: 12/2022

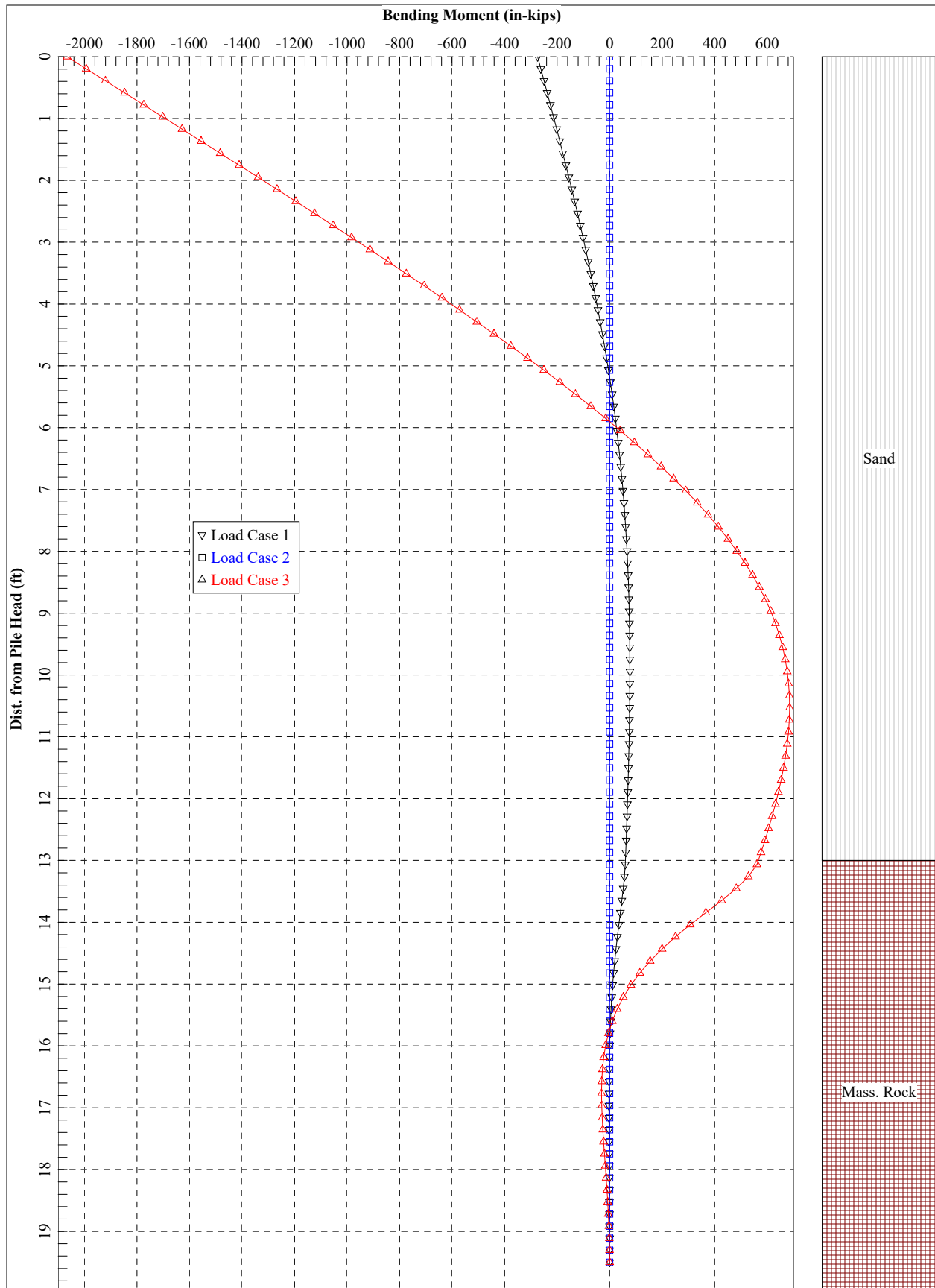


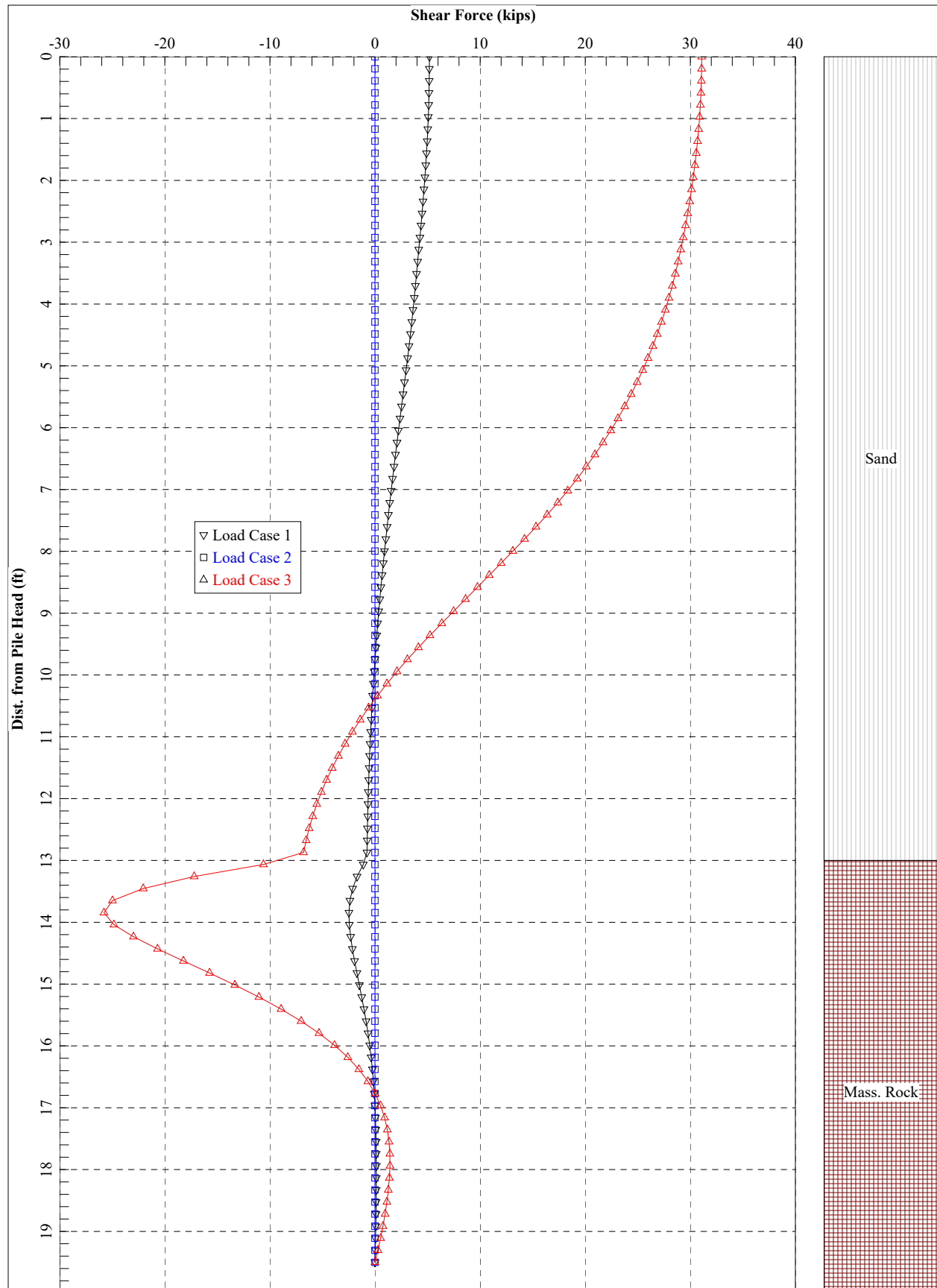
LAMSON ENGINEERING CORPORATION		Final Page No:	
Project:	Bridge No. W-38-003, Wilmington	Job No:	Preliminary Sheet No:
Subject:	Retaining Wall 2 Micropile Foundation	Prepared by: SL	Date: 12/2022
Detail:	Lpile Analysis	Checked by: JG	Date: 12/2022

Based on CWB-14









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LPILE for Windows, Version 2022-12.007

Analysis of Individual Piles and Drilled Shafts
Subjected to Lateral Loading Using the p-y Method
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Files Used for Analysis

Path to file locations:
\\Users\Lamson Engineering\Desktop\Charlie's Lamson Files\Green\W-38-003 (2NV) - Wilmington\6.1 Geotech Report -
Retaining Wall\LPILE\

Name of input data file:
Wilmington W38003_Retaining Wall Type 2 Micropile.lp12d

Name of output report file:
Wilmington W38003_Retaining Wall Type 2 Micropile.lp12o

Name of plot output file:
Wilmington W38003_Retaining Wall Type 2 Micropile.lp12p

Name of runtime message file:
Wilmington W38003_Retaining Wall Type 2 Micropile.lp12r

Date and Time of Analysis

Date: December 24, 2022 Time: 9:05:49

Problem Title

Butters Row Bridge W-38-003, Wilmington

Job Number:

Client: MassDOT

Engineer: Lamson Engineering Corporation

Description: Retaining Wall Type 2 - 10.75 Micropile

Program Options and Settings

Computational Options:

- Conventional Analysis

Engineering Units Used for Data Input and Computations:

- US Customary System Units (pounds, feet, inches)

Analysis Control Options:

- Maximum number of iterations allowed = 500
- Deflection tolerance for convergence = 1.0000E-05 in
- Maximum allowable deflection = 100.0000 in
- Number of pile increments = 100

Loading Type and Number of Cycles of Loading:

- Static loading specified
- Analysis uses p-y modification factors for p-y curves
- Analysis uses layering correction (Method of Georgiadis)
- No distributed lateral loads are entered
- Loading by lateral soil movements acting on pile not selected
- Input of shear resistance at the pile tip not selected
- Input of moment resistance at the pile tip not selected
- Computation of pile-head foundation stiffness matrix not selected
- Push-over analysis of pile not selected
- Buckling analysis of pile not selected

Output Options:

- Output files use decimal points to denote decimal symbols.
- Values of pile-head deflection, bending moment, shear force, and soil reaction are printed for full length of pile.
- Printing Increment (nodal spacing of output points) = 1
- No p-y curves to be computed and reported for user-specified depths
- Print using wide report formats

Pile Structural Properties and Geometry

Number of pile sections defined = 2
Total length of pile = 19.500 ft
Depth of ground surface below top of pile = 0.0000 ft

Pile diameters used for p-y curve computations are defined using 4 points.

p-y curves are computed using pile diameter values interpolated with depth over the length of the pile. A summary of values of pile diameter vs. depth follows.

Point No.	Depth Below Pile Head feet	Pile Diameter inches
1	0.000	10.7500
2	14.000	10.7500
3	14.000	9.5600

4 19.500 9.5600

Input Structural Properties for Pile Sections:

Pile Section No. 1:

Section 1 is a drilled shaft with permanent casing

Length of section = 14.000000 ft

Casing outside diameter = 10.750000 in

Pile Section No. 2:

Section 2 is a round drilled shaft, bored pile, or CIDH pile

Length of section = 5.500000 ft

Shaft Diameter = 9.560000 in

Ground Slope and Pile Batter Angles

Ground Slope Angle = 0.000 degrees

= 0.000 radians

Pile Batter Angle = 0.000 degrees

= 0.000 radians

Soil and Rock Layering Information

The soil profile is modelled using 2 layers

Layer 1 is sand, p-y criteria by Reese et al., 1974

Distance from top of pile to top of layer = 0.0000 ft

Distance from top of pile to bottom of layer = 13.000000 ft

Effective unit weight at top of layer = 57.600000 pcf

Effective unit weight at bottom of layer = 57.600000 pcf

Friction angle at top of layer = 30.000000 deg.

Friction angle at bottom of layer = 30.000000 deg.

Subgrade k at top of layer = 20.000000 pci

Subgrade k at bottom of layer = 20.000000 pci

Layer 2 is massive rock, p-y criteria by Liang et al., 2009

Distance from top of pile to top of layer = 13.000000 ft

Distance from top of pile to bottom of layer = 20.500000 ft

Effective unit weight at top of layer = 165.000000 pcf

Effective unit weight at bottom of layer = 165.000000 pcf

Uniaxial compressive strength at top of layer = 23836. psi

Uniaxial compressive strength at bottom of layer = 23836. psi

Poisson's ratio at top of layer = 0.090000

Poisson's ratio at bottom of layer = 0.090000

Option 1: Intact rock modulus at top of layer = 2480000. psi

Intact rock modulus at bottom of layer = 2480000. psi

Option 1: Geologic Strength Index for layer = 35.000000

Option 2: Rock mass modulus at top of layer = 0.0000 psi

Rock mass modulus at bottom of layer = 0.0000 psi

Option 1 will be used to compute values of rock mass modulus for the p-y curve in massive rock.

The rock type is (igneous) diorite, Hoek-Brown Material Constant $m_i = 25$

(Depth of the lowest soil layer extends 1.000 ft below the pile tip)

**** Warning - Possible Input Data Error ****

Values entered for effective unit weight of rock were outside the limits of 50 pcf to 150 pcf.

The maximum input value, in layer 1, for effective unit weight = 165.00 pcf

This data may be erroneous. Please check your data.

Summary of Input Soil Properties

Layer Geologic Num. Strength Index	Soil Type Int. Rock Name Modulus (p-y Curve Type) psi	Layer Hoek-Brown Depth Material ft Index, mi	Effective Unit Wt. Poisson's pcf Ratio	Angle of Friction deg.	Uniaxial qu psi	kpy pci	Rock Mass Modulus psi
1	Sand 0.00 (Reese, et al.) 0.00	0.00 0.00 13.0000 0.00	57.6000 0.00 57.6000 0.00	30.0000 30.0000	-- --	20.0000 20.0000	-- --
2	Massive 2480000. Rock 2480000.	13.0000 25.0000 20.5000 25.0000	165.0000 0.09000 165.0000 0.09000	-- --	23836. 23836.	-- --	Internally Computed

Modification Factors for p-y Curves

Distribution of p-y modifiers with depth defined using 2 points

Point No.	Depth X ft	p-mult	y-mult
1	0.000	0.8500	1.0000
2	13.000	0.8500	1.0000

Static Loading Type

Static loading criteria were used when computing p-y curves for all analyses.

Pile-head Loading and Pile-head Fixity Conditions

Number of loads specified = 3

Load No.	Load Type	Condition 1	Condition 2	Axial Thrust Force, lbs	Compute Top y vs. Pile Length	Run Analysis
-------------	--------------	----------------	----------------	----------------------------	----------------------------------	--------------

1	2	V =	5180. lbs	S =	0.0000 in/in	137250.	Yes	Yes
2	2	V =	0.0000 lbs	S =	0.0000 in/in	98240.	Yes	Yes
3	5	y =	1.000000 in	S =	0.0000 in/in	98240.	N.A.	Yes

V = shear force applied normal to pile axis

M = bending moment applied to pile head

y = lateral deflection normal to pile axis

S = pile slope relative to original pile batter angle

R = rotational stiffness applied to pile head

Values of top y vs. pile lengths can be computed only for load types with specified shear loading (Load Types 1, 2, and 3).

Thrust force is assumed to be acting axially for all pile batter angles.

 Computations of Nominal Moment Capacity and Nonlinear Bending Stiffness

Axial thrust force values were determined from pile-head loading conditions

Number of Pile Sections Analyzed = 2

Pile Section No. 1:

Dimensions and Properties of Drilled Shaft (Bored Pile) with Permanent Casing:

Length of Section	=	14.000000 ft
Outer Diameter of Casing	=	10.750000 in
Concrete Cover Thickness Inside Casing	=	3.655000 in
Casing Wall Thickness	=	0.595000 in
Moment of Inertia of Steel Casing	=	245.530255 in^4
Yield Stress of Casing	=	52000. psi
Elastic Modulus of Casing	=	29000000. psi
Number of Reinforcing Bars	=	1 bar
Area of Single Reinforcing Bar	=	2.250000 sq. in.
Edge-to-Edge Bar Spacing	=	-1.69300 in
Maximum Concrete Aggregate Size	=	0.375000 in
Ratio of Bar Spacing to Aggregate Size	=	-4.51
Offset of Center of Rebar Cage from Center of Pile	=	0.0000 in
Yield Stress of Reinforcing Bars	=	60000. psi
Modulus of Elasticity of Reinforcing Bars	=	29000000. psi
Gross Area of Pile	=	90.762575 sq. in.
Area of Concrete	=	69.530366 sq. in.
Cross-sectional Area of Steel Casing	=	18.982210 sq. in.
Area of All Steel (Casing and Bars)	=	21.232210 sq. in.
Area Ratio of All Steel to Gross Area of Pile	=	23.39 percent

Axial Structural Capacities:

Nom. Axial Structural Capacity = $0.85 F_c A_c + F_y A_s$	=	1417.579 kips
Tensile Load for Cracking of Concrete	=	-103.016 kips
Nominal Axial Tensile Capacity	=	-1122.075 kips

Reinforcing Bar Dimensions and Positions Used in Computations:

Bar Number	Bar Diam. inches	Bar Area sq. in.	X inches	Y inches
-----	-----	-----	-----	-----
1	1.693000	2.250000	0.00000	0.00000

NOTE: The positions of the above rebars were computed by LPile

Concrete Properties:

Compressive Strength of Concrete	=	5000. psi
Modulus of Elasticity of Concrete	=	4030509. psi
Modulus of Rupture of Concrete	=	-530.33009 psi
Compression Strain at Peak Stress	=	0.002109
Tensile Strain at Fracture of Concrete	=	-0.0001150
Maximum Coarse Aggregate Size	=	0.375000 in

Number of Axial Thrust Force Values Determined from Pile-head Loadings = 2

Number	Axial Thrust Force kips
-----	-----
1	98.240
2	137.250

Definitions of Run Messages and Notes:

C = concrete in section has cracked in tension.
Y = stress in reinforcing steel has reached yield stress.
T = ACI 318 criteria for tension-controlled section met, tensile strain in reinforcement exceeds 0.005 while simultaneously compressive strain in concrete more than 0.003. See ACI 318-14, Section 21.2.3.
Z = depth of tensile zone in concrete section is less than 10 percent of section depth.

Bending Stiffness (EI) = Computed Bending Moment / Curvature.
Position of neutral axis is measured from edge of compression side of pile.
Compressive stresses and strains are positive in sign.
Tensile stresses and strains are negative in sign.

Axial Thrust Force = 98.240 kips

Bending Max Casing Run Curvature Stress Msg rad/in. ksi	Bending Moment in-kip	Bending Stiffness kip-in2	Depth to N Axis in	Max Comp Strain in/in	Max Tens Strain in/in	Max Conc Stress ksi	Max Steel Stress ksi
-----	-----	-----	-----	-----	-----	-----	-----
0.00000125	11.2241694	8979335.	89.2305075	0.0001115	0.00009810	0.5146008	3.0689887
3.2326575							
0.00000250	22.4471060	8978842.	47.3036770	0.0001183	0.00009138	0.5444345	3.0982822
3.4256197							
0.00000375	33.6700320	8978675.	33.3284799	0.0001250	0.00008467	0.5741755	3.1276206
3.6186269							
0.00000500	44.8929420	8978588.	26.3411912	0.0001317	0.00007796	0.6038239	3.1570040
3.8116790							
0.00000625	56.1158306	8978533.	22.1490659	0.0001384	0.00007124	0.6333795	3.1864323
4.0047760							
0.00000750	67.3386926	8978492.	19.3545222	0.0001452	0.00006453	0.6628422	3.2159055
4.1979180							
0.00000875	78.5615224	8978460.	17.3585967	0.0001519	0.00005783	0.6922120	3.2454236
4.3911049							
0.00001000	89.7843149	8978431.	15.8618074	0.0001586	0.00005112	0.7214888	3.2749867
4.5843367							
0.00001125	101.0070646	8978406.	14.6977757	0.0001653	0.00004441	0.7506726	3.3045947
4.7776134							
0.00001250	112.2297663	8978381.	13.7666743	0.0001721	0.00003771	0.7797632	3.3342476
4.9709351							
0.00001375	123.4524144	8978357.	13.0049768	0.0001788	0.00003101	0.8087607	3.3639455
5.1643017							

0.00001500	134.6750037	8978334.	12.3703321	0.0001856	0.00002430	0.8376649	3.3936882
5.3577132							
0.00001625	145.8975289	8978309.	11.8334204	0.0001923	0.00001761	0.8664757	3.4234760
5.5511697							
0.00001750	157.1199848	8978285.	11.3732989	0.0001990	0.00001091	0.8951931	3.4533081
5.7446706							
0.00001875	168.3423656	8978259.	10.9746095	0.0002058	0.00000421	0.9238171	3.4831858
5.9382170							
0.00002000	179.5646661	8978233.	10.6258338	0.0002125	-0.00000248	0.9523476	3.5131083
6.1318083							
0.00002125	190.7868811	8978206.	10.3181635	0.0002193	-0.00000918	0.9807844	3.5430758
6.3254445							
0.00002250	202.0090017	8978178.	10.0447476	0.0002260	-0.00001587	1.0091276	3.5730885
6.5191260							
0.00002375	213.2308803	8978142.	9.8001761	0.0002328	-0.00002256	1.0373769	3.6031448
6.7128510							
0.00002500	224.4520838	8978083.	9.5801182	0.0002395	-0.00002925	1.0655317	3.6332421
6.9066171							
0.00002625	235.6721147	8977985.	9.3810674	0.0002463	-0.00003593	1.0935916	3.6633767
7.1004205							
0.00002750	246.8905052	8977837.	9.2001546	0.0002530	-0.00004262	1.1215560	3.6935453
7.2942578							
0.00002875	258.1068463	8977629.	9.0350100	0.0002598	-0.00004931	1.1494243	3.7237444
7.4881256							
0.00003000	269.3207779	8977359.	8.8836593	0.0002665	-0.00005599	1.1771960	3.7539711
7.6820211							
0.00003125	280.5319998	8977024.	8.7444441	0.0002733	-0.00006267	1.2048708	3.7842229
7.8759416							
0.00003250	291.7402475	8976623.	8.6159618	0.0002800	-0.00006936	1.2324483	3.8144972
8.0698847							
0.00003375	302.9453018	8976157.	8.4970177	0.0002868	-0.00007604	1.2599281	3.8447921
8.2638484							
0.00003500	314.1469750	8975628.	8.3865881	0.0002935	-0.00008272	1.2873100	3.8751057
8.4578307							
0.00003625	325.3451067	8975037.	8.2837905	0.0003003	-0.00008940	1.3145936	3.9054364
8.6518302							
0.00003750	336.5395595	8974388.	8.1878604	0.0003070	-0.00009608	1.3417789	3.9357827
8.8458452							
0.00003875	347.7302149	8973683.	8.0981322	0.0003138	-0.000103	1.3688654	3.9661434
9.0398746							
0.00004000	358.9169693	8972924.	8.0140233	0.0003206	-0.000109	1.3958532	3.9965172
9.2339172							
0.00004125	361.1192586	8754406.	7.8729590	0.0003248	-0.000119	1.4124665	3.9526601
9.3537289 C							
0.00004250	371.3196758	8736934.	7.7932810	0.0003312	-0.000126	1.4380772	3.9742346
9.5389721 C							
0.00004375	381.4822776	8719595.	7.7178126	0.0003377	-0.000133	1.4635362	3.9953733
9.7237796 C							
0.00004500	391.6239247	8702754.	7.6463595	0.0003441	-0.000140	1.4888722	4.0162805
9.9083555 C							
0.00004625	401.7489547	8686464.	7.5786388	0.0003505	-0.000147	1.5140934	4.0370142
10.0927580 C							
0.00004750	411.8401608	8670319.	7.5141758	0.0003569	-0.000154	1.5391661	4.0573242
10.2767367 C							
0.00004875	421.9206242	8654782.	7.4529424	0.0003633	-0.000161	1.5641337	4.0775272
10.4606084 C							
0.00005125	442.0220467	8624820.	7.3389456	0.0003761	-0.000175	1.6136997	4.1172034
10.8276222 C							
0.00005375	462.0625567	8596513.	7.2350778	0.0003889	-0.000189	1.6628066	4.1561387
11.1938949 C							
0.00005625	482.0509976	8569796.	7.1400515	0.0004016	-0.000203	1.7114701	4.1944358
11.5595295 C							
0.00005875	501.9895856	8544504.	7.0527387	0.0004143	-0.000217	1.7596924	4.2320960
11.9245272 C							
0.00006125	521.8838560	8520553.	6.9722269	0.0004270	-0.000231	1.8074828	4.2691760
12.2889447 C							
0.00006375	541.7458798	8497975.	6.8978207	0.0004397	-0.000246	1.8548680	4.3058696
12.6529758 C							
0.00006625	561.5810216	8476695.	6.8288779	0.0004524	-0.000260	1.9018612	4.3422709

13.0167147 C							
0.00006875	581.3749885	8456363.	6.7646462	0.0004651	-0.000274	1.9484236	4.3780683
13.3798495 C							
0.00007125	601.1532083	8437238.	6.7048716	0.0004777	-0.000288	1.9946202	4.4137615
13.7428802 C							
0.00007375	620.9002012	8418986.	6.6489445	0.0004904	-0.000302	2.0404094	4.4490162
14.1054725 C							
0.00007625	640.6323633	8401736.	6.5966397	0.0005030	-0.000317	2.0858346	4.4841712
14.4679650 C							
0.00007875	660.3373906	8385237.	6.5474880	0.0005156	-0.000331	2.1308610	4.5189432
14.8300744 C							
0.00008125	680.0344132	8369654.	6.5013839	0.0005282	-0.000345	2.1755435	4.5537689
15.1922377 C							
0.00008375	699.7009159	8354638.	6.4578251	0.0005408	-0.000359	2.2198139	4.5880914
15.5538977 C							
0.00008625	719.3607381	8340414.	6.4168257	0.0005535	-0.000374	2.2637450	4.6224996
15.9156433 C							
0.00008875	739.0034843	8326800.	6.3780613	0.0005661	-0.000388	2.3073032	4.6567153
16.2771965 C							
0.00009125	758.6280671	8313732.	6.3413370	0.0005786	-0.000402	2.3504854	4.6907087
16.6385274 C							
0.00009375	778.2459662	8301290.	6.3066027	0.0005912	-0.000417	2.3933287	4.7247872
16.9999434 C							
0.00009625	797.8484715	8289335.	6.2736122	0.0006038	-0.000431	2.4358029	4.7586968
17.3611905 C							
0.00009875	817.4342433	8277815.	6.2422192	0.0006164	-0.000445	2.4779040	4.7923976
17.7222289 C							
0.0001013	837.0133317	8266798.	6.2124053	0.0006290	-0.000459	2.5196663	4.8261832
18.0833519 C							
0.0001038	856.5857019	8256248.	6.1840564	0.0006416	-0.000474	2.5610893	4.8600506
18.4445568 C							
0.0001063	876.1378832	8246004.	6.1569282	0.0006542	-0.000488	2.6021244	4.8935719
18.8054156 C							
0.0001088	895.6818494	8236155.	6.1310585	0.0006668	-0.000502	2.6428152	4.9271284
19.1663097 C							
0.0001113	915.2191254	8226689.	6.1063777	0.0006793	-0.000517	2.6831672	4.9607695
19.5272882 C							
0.0001138	934.7497030	8217580.	6.0828073	0.0006919	-0.000531	2.7231802	4.9944951
19.8883514 C							
0.0001163	954.2664795	8208744.	6.0602009	0.0007045	-0.000545	2.7628263	5.0280526
20.2492464 C							
0.0001188	973.7718974	8200184.	6.0385226	0.0007171	-0.000559	2.8021153	5.0615283
20.6100596 C							
0.0001213	993.2706182	8191923.	6.0177623	0.0007297	-0.000574	2.8410653	5.0950886
20.9709574 C							
0.0001238	1013.	8183940.	5.9978644	0.0007422	-0.000588	2.8796761	5.1287335
21.3319398 C							
0.0001263	1032.	8176221.	5.9787777	0.0007548	-0.000602	2.9179475	5.1624632
21.6930069 C							
0.0001288	1052.	8168727.	5.9604233	0.0007674	-0.000617	2.9558669	5.1961606
22.0540419 C							
0.0001313	1071.	8161419.	5.9427247	0.0007800	-0.000631	2.9934205	5.2296907
22.4149095 C							
0.0001338	1091.	8154334.	5.9257096	0.0007926	-0.000645	3.0306348	5.2633067
22.7758629 C							
0.0001363	1110.	8147460.	5.9093404	0.0008051	-0.000660	3.0675094	5.2970075
23.1369013 C							
0.0001388	1130.	8140785.	5.8935822	0.0008177	-0.000674	3.1040440	5.3307934
23.4980247 C							
0.0001413	1149.	8134299.	5.8784026	0.0008303	-0.000688	3.1402385	5.3646644
23.8592332 C							
0.0001438	1168.	8127992.	5.8637715	0.0008429	-0.000702	3.1760926	5.3986207
24.2205270 C							
0.0001463	1188.	8121823.	5.8496116	0.0008555	-0.000717	3.2115857	5.4324542
24.5816979 C							
0.0001488	1207.	8115799.	5.8359213	0.0008681	-0.000731	3.2467273	5.4662600
24.9428413 C							
0.0001588	1285.	8093176.	5.7856577	0.0009185	-0.000788	3.3838866	5.6023390
26.3882703 C							

0.0001688	1362.	8072564.	5.7415804	0.0009689	-0.000845	3.5155600	5.7395392
27.8348204 C							
0.0001788	1440.	8053562.	5.7025376	0.0010193	-0.000902	3.6416844	5.8772717
29.2819030 C							
0.0001888	1517.	8035995.	5.6678854	0.0010698	-0.000959	3.7623232	6.0163928
30.7303741 C							
0.0001988	1594.	8019627.	5.6369259	0.0011203	-0.001016	3.8774446	6.1566994
32.1800306 C							
0.0002088	1671.	8004249.	5.6090476	0.0011709	-0.001073	3.9869988	6.2977020
33.6303833 C							
0.0002188	1748.	7989772.	5.5839409	0.0012215	-0.001130	4.0910277	6.4401176
35.0821488 C							
0.0002288	1825.	7976076.	5.5612434	0.0012721	-0.001187	4.1895153	6.5839537
36.5353349 C							
0.0002388	1901.	7963060.	5.5406536	0.0013228	-0.001244	4.2824455	6.7292182
37.9899495 C							
0.0002488	1978.	7950614.	5.5218405	0.0013736	-0.001301	4.3697696	6.8753573
39.4454386 C							
0.0002588	2054.	7938688.	5.5046525	0.0014243	-0.001357	4.4514994	7.0227791
40.9022103 C							
0.0002688	2130.	7927229.	5.4889304	0.0014752	-0.001414	4.5276286	7.1716569
42.3604381 C							
0.0002788	2207.	7916186.	5.4745175	0.0015260	-0.001471	4.5981406	7.3219989
43.8201302 C							
0.0002888	2283.	7905513.	5.4612788	0.0015769	-0.001527	4.6630187	7.4738136
45.2812949 C							
0.0002988	2359.	7895170.	5.4490973	0.0016279	-0.001584	4.7222458	7.6271094
46.7439406 C							
0.0003088	2435.	7885125.	5.4378712	0.0016789	-0.001640	4.7758049	7.7818947
48.2080759 C							
0.0003188	2510.	7875345.	5.4275047	0.0017300	-0.001697	4.8236768	7.9381150
49.6736462 C							
0.0003288	2586.	7865796.	5.4178805	0.0017811	-0.001753	4.8658348	8.0953984
51.1402797 C							
0.0003388	2661.	7855060.	5.4093624	0.0018324	-0.001809	4.9023627	8.2579675
52.0000000 CY							
0.0003488	2732.	7832874.	5.4016664	0.0018838	-0.001865	4.9331621	8.4239095
52.0000000 CY							
0.0003588	2796.	7792354.	5.3947102	0.0019354	-0.001921	4.9581909	8.5930839
52.0000000 CY							
0.0003688	2851.	7731856.	5.3877807	0.0019867	-0.001977	4.9773340	8.7585104
52.0000000 CY							
0.0003788	2898.	7652602.	5.3804305	0.0020378	-0.002034	4.9906011	8.9152889
52.0000000 CY							
0.0003888	2939.	7560828.	5.3729807	0.0020887	-0.002090	4.9981043	-9.112227
52.0000000 CY							
0.0003988	2975.	7462064.	5.3655855	0.0021395	-0.002147	4.9987243	-9.432139
52.0000000 CY							
0.0004088	3008.	7359086.	5.3582931	0.0021902	-0.002204	4.9990827	-9.755124
52.0000000 CY							
0.0004188	3037.	7253688.	5.3511235	0.0022408	-0.002261	4.9992582	-10.080847
52.0000000 CY							
0.0004288	3064.	7147136.	5.3440850	0.0022913	-0.002318	4.9992948	-10.409099
52.0000000 CY							
0.0004388	3089.	7040364.	5.3371794	0.0023417	-0.002375	4.9992022	-10.739742
52.0000000 CY							
0.0004488	3112.	6933864.	5.3305232	0.0023921	-0.002432	4.9989606	-11.071145
52.0000000 CY							
0.0004588	3132.	6828015.	5.3242229	0.0024425	-0.002489	4.9985190	-11.401673
52.0000000 CY							
0.0004688	3152.	6723563.	5.3180656	0.0024928	-0.002546	4.9977846	-11.733912
52.0000000 CY							
0.0004788	3170.	6620824.	5.3120465	0.0025431	-0.002603	4.9999883	-12.067803
52.0000000 CY							
0.0004888	3186.	6519513.	5.3065506	0.0025936	-0.002660	4.9997645	-12.397770
52.0000000 CY							
0.0004988	3202.	6419686.	5.3009938	0.0026439	-0.002718	4.9991181	-12.731805
52.0000000 CY							
0.0005088	3216.	6322118.	5.2955835	0.0026941	-0.002775	4.9978502	-13.066901

52.0000000 CY							
0.0005188	3230.	6226295.	5.2908206	0.0027446	-0.002832	4.9999647	-13.395396
52.0000000 CY							
0.0005288	3243.	6132579.	5.2859124	0.0027949	-0.002889	4.9993254	-13.728882
52.0000000 CY							
0.0005388	3254.	6040664.	5.2813769	0.0028453	-0.002946	4.9976793	-14.059391
52.0000000 CY							
0.0005488	3266.	5951194.	5.2771223	0.0028958	-0.003003	4.9998992	-14.388061
52.0000000 CY							
0.0006088	3320.	5454294.	5.2547375	0.0031988	-0.003345	4.9965615	-16.356419
52.0000000 CY							
0.0006688	3359.	5023227.	5.2384453	0.0035032	-0.003686	4.9999355	-18.284517
52.0000000 CY							
0.0007288	3388.	4649062.	5.2265931	0.0038089	-0.004025	4.9955805	-20.175478
52.0000000 CY							

Axial Thrust Force = 137.250 kips

Bending Max Casing Run Curvature Stress rad/in. ksi	Bending Moment in-kip	Bending Stiffness kip-in2	Depth to N Axis in	Max Comp Strain in/in	Max Tens Strain in/in	Max Conc Stress ksi	Max Steel Stress ksi
0.00000125	11.1761459	8940917.	122.9415310	0.0001537	0.0001402	0.7018557	4.2910133
4.4546821							
0.00000250	22.3505622	8940225.	64.1591953	0.0001604	0.0001335	0.7310590	4.3203073
4.6476448							
0.00000375	33.5249677	8939991.	44.5654994	0.0001671	0.0001268	0.7601696	4.3496465
4.8406528							
0.00000500	44.6993572	8939871.	34.7689636	0.0001738	0.0001201	0.7891874	4.3790310
5.0337060							
0.00000625	55.8737252	8939796.	28.8912917	0.0001806	0.0001134	0.8181123	4.4084607
5.2268045							
0.00000750	67.0480662	8939742.	24.9730518	0.0001873	0.0001067	0.8469442	4.4379357
5.4199482							
0.00000875	78.2223750	8939700.	22.1744874	0.0001940	0.00009996	0.8756832	4.4674559
5.6131371							
0.00001000	89.3966461	8939665.	20.0757201	0.0002008	0.00009326	0.9043290	4.4970214
5.8063714							
0.00001125	100.5708742	8939633.	18.4434842	0.0002075	0.00008655	0.9328818	4.5266321
5.9996508							
0.00001250	111.7450538	8939604.	17.1378204	0.0002142	0.00007985	0.9613412	4.5562880
6.1929755							
0.00001375	122.9191795	8939577.	16.0696634	0.0002210	0.00007315	0.9897074	4.5859893
6.3863455							
0.00001500	134.0932461	8939550.	15.1796366	0.0002277	0.00006644	1.0179802	4.6157357
6.5797607							
0.00001625	145.2672480	8939523.	14.4266331	0.0002344	0.00005975	1.0461596	4.6455274
6.7732212							
0.00001750	156.4411799	8939496.	13.7812906	0.0002412	0.00005305	1.0742455	4.6753644
6.9667269							
0.00001875	167.6150363	8939469.	13.2220771	0.0002479	0.00004635	1.1022378	4.7052466
7.1602779							
0.00002000	178.7888120	8939441.	12.7328432	0.0002547	0.00003966	1.1301365	4.7351741
7.3538741							
0.00002125	189.9625015	8939412.	12.3012397	0.0002614	0.00003296	1.1579414	4.7651468
7.5475156							
0.00002250	201.1360995	8939382.	11.9176615	0.0002681	0.00002627	1.1856525	4.7951648
7.7412023							
0.00002375	212.3096004	8939352.	11.5745257	0.0002749	0.00001958	1.2132698	4.8252281
7.9349343							
0.00002500	223.4829990	8939320.	11.2657658	0.0002816	0.00001289	1.2407932	4.8553365
8.1287115							
0.00002625	234.6562899	8939287.	10.9864711	0.0002884	0.00000621	1.2682226	4.8854903
8.3225340							

0.00002750	245.8294676	8939253.	10.7326236	0.0002951	-4.77850E-07	1.2955579	4.9156893
8.5164018							
0.00002875	257.0025268	8939218.	10.5009041	0.0003019	-0.00000716	1.3227990	4.9459336
8.7103148							
0.00003000	268.1754620	8939182.	10.2885465	0.0003087	-0.00001384	1.3499460	4.9762231
8.9042731							
0.00003125	279.3482659	8939145.	10.0932275	0.0003154	-0.00002052	1.3769987	5.0065578
9.0982766							
0.00003250	290.5208604	8939103.	9.9129805	0.0003222	-0.00002720	1.4039569	5.0369374
9.2923249							
0.00003375	301.6929716	8939051.	9.7461290	0.0003289	-0.00003388	1.4308204	5.0673598
9.4864160							
0.00003500	312.8642555	8938979.	9.5912353	0.0003357	-0.00004056	1.4575888	5.0978227
9.6805477							
0.00003625	324.0343509	8938879.	9.4470600	0.0003425	-0.00004723	1.4842616	5.1283235
9.8747173							
0.00003750	335.2029253	8938745.	9.3125289	0.0003492	-0.00005391	1.5108385	5.1588597
10.0689222							
0.00003875	346.3696687	8938572.	9.1867065	0.0003560	-0.00006058	1.5373189	5.1894287
10.2631600							
0.00004000	357.5342957	8938357.	9.0687744	0.0003628	-0.00006725	1.5637027	5.2200284
10.4574284							
0.00004125	368.6965528	8938098.	8.9580136	0.0003695	-0.00007392	1.5899894	5.2506567
10.6517254							
0.00004250	379.8562131	8937793.	8.8537896	0.0003763	-0.00008059	1.6161788	5.2813114
10.8460489							
0.00004375	391.0130734	8937442.	8.7555408	0.0003831	-0.00008726	1.6422705	5.3119910
11.0403972							
0.00004500	402.1669523	8937043.	8.6627680	0.0003898	-0.00009393	1.6682643	5.3426936
11.2347686							
0.00004625	413.3176918	8936599.	8.5750260	0.0003966	-0.000101	1.6941600	5.3734178
11.4291616							
0.00004750	424.4651495	8936108.	8.4919167	0.0004034	-0.000107	1.7199574	5.4041623
11.6235748							
0.00004875	435.6091952	8935573.	8.4130828	0.0004101	-0.000114	1.7456561	5.4349257
11.8180069							
0.00005125	450.2323243	8785021.	8.2256073	0.0004216	-0.000129	1.7887035	5.4350043
12.1454230 C							
0.00005375	470.7711172	8758532.	8.0853987	0.0004346	-0.000143	1.8375130	5.4815763
12.5193325 C							
0.00005625	491.2044515	8732524.	7.9570154	0.0004476	-0.000157	1.8858146	5.5271081
12.8922019 C							
0.00005875	511.5434493	8707123.	7.8389956	0.0004605	-0.000171	1.9336217	5.5716811
13.2641124 C							
0.00006125	531.7980332	8682417.	7.7301134	0.0004735	-0.000185	1.9809469	5.6153720
13.6351408 C							
0.00006375	551.9779343	8658477.	7.6293395	0.0004864	-0.000199	2.0278035	5.6582650
14.0053713 C							
0.00006625	572.0925879	8635360.	7.5358035	0.0004992	-0.000213	2.0742052	5.7004516
14.3748954 C							
0.00006875	592.1510369	8613106.	7.4487650	0.0005121	-0.000227	2.1201664	5.7420300
14.7438113 C							
0.00007125	612.1591403	8591707.	7.3675705	0.0005249	-0.000241	2.1656966	5.7830631
15.1121818 C							
0.00007375	632.1080279	8570956.	7.2915462	0.0005378	-0.000255	2.2107767	5.8233805
15.4798368 C							
0.00007625	652.0214125	8551100.	7.2203398	0.0005506	-0.000269	2.2554505	5.8633282
15.8471219 C							
0.00007875	671.9031230	8532103.	7.1535186	0.0005633	-0.000283	2.2997264	5.9029654
16.2140967 C							
0.00008125	691.7345934	8513657.	7.0905325	0.0005761	-0.000297	2.3435645	5.9419503
16.5804191 C							
0.00008375	711.5484590	8496101.	7.0312660	0.0005889	-0.000311	2.3870322	5.9808360
16.9466423 C							
0.00008625	731.3200052	8479073.	6.9752143	0.0006016	-0.000326	2.4300764	6.0191692
17.3123129 C							
0.00008875	751.0761773	8462830.	6.9222923	0.0006144	-0.000340	2.4727548	6.0574298
17.6779110 C							
0.00009125	770.7951701	8447070.	6.8720836	0.0006271	-0.000354	2.5150189	6.0951967

18.0430155 C							
0.00009375	790.5060963	8432065.	6.8245769	0.0006398	-0.000368	2.5569341	6.1330295
18.4081858 C							
0.00009625	810.1763449	8417417.	6.7793217	0.0006525	-0.000382	2.5984244	6.1702585
18.7727522 C							
0.00009875	829.8397748	8403441.	6.7363895	0.0006652	-0.000396	2.6395695	6.2075779
19.1374092 C							
0.0001013	849.4783648	8389910.	6.6954737	0.0006779	-0.000411	2.6803252	6.2445928
19.5017615 C							
0.0001038	869.0967402	8376836.	6.6564620	0.0006906	-0.000425	2.7207034	6.2814036
19.8659099 C							
0.0001063	888.7082793	8364313.	6.6193151	0.0007033	-0.000439	2.7607370	6.3183040
20.2301478 C							
0.0001088	908.2913903	8352105.	6.5837433	0.0007160	-0.000453	2.8003704	6.3547855
20.5939667 C							
0.0001113	927.8614444	8340328.	6.5497524	0.0007287	-0.000467	2.8396437	6.3912092
20.9577279 C							
0.0001138	947.4246509	8329008.	6.5172824	0.0007413	-0.000481	2.8785726	6.4277215
21.3215778 C							
0.0001163	966.9671295	8317997.	6.4861307	0.0007540	-0.000496	2.9171198	6.4639700
21.6851638 C							
0.0001188	986.4922763	8307303.	6.4562389	0.0007667	-0.000510	2.9552949	6.5000401
22.0485714 C							
0.0001213	1006.	8296994.	6.4276047	0.0007793	-0.000524	2.9931261	6.5361982
22.4120669 C							
0.0001238	1026.	8287046.	6.4001520	0.0007920	-0.000538	3.0306130	6.5724443
22.7756506 C							
0.0001263	1045.	8277296.	6.3736749	0.0008047	-0.000553	3.0677049	6.6082815
23.1388252 C							
0.0001288	1064.	8267846.	6.3482267	0.0008173	-0.000567	3.1044445	6.6441215
23.5020027 C							
0.0001313	1084.	8258705.	6.3237710	0.0008300	-0.000581	3.1408402	6.6800490
23.8652678 C							
0.0001338	1103.	8249853.	6.3002521	0.0008427	-0.000595	3.1768918	6.7160642
24.2286205 C							
0.0001363	1123.	8241211.	6.2775503	0.0008553	-0.000609	3.2125726	6.7518978
24.5917915 C							
0.0001388	1142.	8232765.	6.2556205	0.0008680	-0.000624	3.2478828	6.7875455
24.9547768 C							
0.0001413	1162.	8224570.	6.2344882	0.0008806	-0.000638	3.2828491	6.8232806
25.3178493 C							
0.0001438	1181.	8216612.	6.2141119	0.0008933	-0.000652	3.3174713	6.8591030
25.6810093 C							
0.0001463	1201.	8208878.	6.1944529	0.0009059	-0.000666	3.3517490	6.8950130
26.0442567 C							
0.0001488	1220.	8201329.	6.1754409	0.0009186	-0.000680	3.3856685	6.9308635
26.4074448 C							
0.0001588	1297.	8172826.	6.1052840	0.0009692	-0.000737	3.5177799	7.0738154
27.8597467 C							
0.0001688	1375.	8146915.	6.0435587	0.0010199	-0.000794	3.6443013	7.2173429
29.3126242 C							
0.0001788	1452.	8123160.	5.9888527	0.0010705	-0.000851	3.7652268	7.3614563
30.7660876 C							
0.0001888	1529.	8101234.	5.9400567	0.0011212	-0.000908	3.8805523	7.5061891
32.2201704 C							
0.0001988	1606.	8080876.	5.8963040	0.0011719	-0.000965	3.9902813	7.6516889
33.6750201 C							
0.0002088	1683.	8061927.	5.8569684	0.0012226	-0.001021	4.0944465	7.7985527
35.1312339 C							
0.0002188	1760.	8044086.	5.8212678	0.0012734	-0.001078	4.1929583	7.9456597
36.5876910 C							
0.0002288	1836.	8027313.	5.7889051	0.0013242	-0.001135	4.2858876	8.0942039
38.0455851 C							
0.0002388	1913.	8011471.	5.7594619	0.0013751	-0.001191	4.3732180	8.2441921
39.5049234 C							
0.0002488	1989.	7996395.	5.7324849	0.0014260	-0.001248	4.4548932	8.3948932
40.9649744 C							
0.0002588	2065.	7982023.	5.7077463	0.0014769	-0.001305	4.5309266	8.5467439
42.4261752 C							

0.0002688	2141.	7968294.	5.6850372	0.0015279	-0.001361	4.6013196	8.7000637
43.8888450 C							
0.0002788	2217.	7955137.	5.6641402	0.0015789	-0.001418	4.6660552	8.8548609
45.3529921 C							
0.0002888	2293.	7942491.	5.6448680	0.0016300	-0.001474	4.7251165	9.0111436
46.8186248 C							
0.0002988	2369.	7930267.	5.6269662	0.0016811	-0.001531	4.7784588	9.1681218
48.2849531 C							
0.0003088	2445.	7918454.	5.6103865	0.0017322	-0.001587	4.8260969	9.3265540
49.7527353 C							
0.0003188	2520.	7907015.	5.5950109	0.0017834	-0.001643	4.8680155	9.4865004
51.2220317 C							
0.0003288	2595.	7894260.	5.5811769	0.0018348	-0.001699	4.9042931	9.6522260
52.0000000 CY							
0.0003388	2668.	7874989.	5.5702195	0.0018869	-0.001755	4.9351310	9.8381872
52.0000000 CY							
0.0003488	2736.	7845309.	5.5632111	0.0019402	-0.001809	4.9604806	10.0577315
52.0000000 CY							
0.0003588	2799.	7801215.	5.5587183	0.0019942	-0.001862	4.9798112	10.2993818
52.0000000 CY							
0.0003688	2854.	7740121.	5.5556454	0.0020486	-0.001915	4.9927886	10.5536126
52.0000000 CY							
0.0003788	2903.	7664401.	5.5528562	0.0021031	-0.001968	4.9992325	10.8091772
52.0000000 CY							
0.0003888	2946.	7577087.	5.5491300	0.0021572	-0.002022	4.9997676	11.0525606
52.0000000 CY							
0.0003988	2983.	7480056.	5.5438622	0.0022106	-0.002076	4.9999664	11.2759544
52.0000000 CY							
0.0004088	3016.	7378088.	5.5380382	0.0022637	-0.002130	4.9995716	11.4897015
52.0000000 CY							
0.0004188	3046.	7273434.	5.5319415	0.0023165	-0.002185	4.9982012	11.6967584
52.0000000 CY							
0.0004288	3073.	7167455.	5.5257148	0.0023692	-0.002240	4.9982589	11.8986626
52.0000000 CY							
0.0004388	3098.	7060723.	5.5196686	0.0024218	-0.002295	4.9981192	12.0992522
52.0000000 CY							
0.0004488	3121.	6954316.	5.5136841	0.0024743	-0.002350	4.9984273	12.2971371
52.0000000 CY							
0.0004588	3142.	6848536.	5.5076550	0.0025266	-0.002405	4.9999976	12.4909577
52.0000000 CY							
0.0004688	3161.	6743916.	5.5016341	0.0025789	-0.002460	4.9999142	12.6813934
52.0000000 CY							
0.0004788	3179.	6640501.	5.4959644	0.0026312	-0.002515	4.9996312	12.8732147
52.0000000 CY							
0.0004888	3196.	6538810.	5.4905261	0.0026835	-0.002571	4.9990125	13.0650259
52.0000000 CY							
0.0004988	3212.	6439245.	5.4851960	0.0027357	-0.002626	4.9978855	13.2552470
52.0000000 CY							
0.0005088	3226.	6340852.	5.4800140	0.0027880	-0.002681	4.9999763	13.4445631
52.0000000 CY							
0.0005188	3239.	6244657.	5.4750041	0.0028402	-0.002736	4.9994758	13.6334620
52.0000000 CY							
0.0005288	3252.	6150714.	5.4702957	0.0028924	-0.002792	4.9981391	13.8240762
52.0000000 CY							
0.0005388	3264.	6058318.	5.4656452	0.0029446	-0.002847	4.9999813	14.0128687
52.0000000 CY							
0.0005488	3275.	5968271.	5.4611247	0.0029968	-0.002902	4.9992119	14.2010287
52.0000000 CY							
0.0006088	3329.	5468777.	5.4380997	0.0033104	-0.003234	4.9999064	15.3472843
52.0000000 CY							
0.0006688	3368.	5035689.	5.4201315	0.0036247	-0.003564	4.9989983	16.5114824
52.0000000 CY							
0.0007288	3395.	4659276.	5.4063250	0.0039399	-0.003894	4.9998862	17.7011035
52.0000000 CY							

Summary of Results for Nominal Moment Capacity for Section 1

Moment values interpolated at maximum compressive strain = 0.003
or maximum developed moment if pile fails at smaller strains.

Load No.	Axial Thrust kips	Nominal Mom. Cap. in-kip	Max. Comp. Strain	Max. Tens. Strain
1	98.240	3284.485	0.00300000	-0.00312083
2	137.250	3275.641	0.00300000	-0.00290566

Note that the values of moment capacity in the table above are not factored by a strength reduction factor (phi-factor).

In ACI 318, the value of the strength reduction factor depends on whether the transverse reinforcing steel bars are tied hoops (0.65) or spirals (0.75).

The above values should be multiplied by the appropriate strength reduction factor to compute ultimate moment capacity according to ACI 318, or the value required by the design standard being followed.

The following table presents factored moment capacities and corresponding bending stiffnesses computed for common resistance factor values used for reinforced concrete sections.

Axial Load No.	Resist. Factor	Nominal Ax. Thrust kips	Nominal Moment Cap in-kips	Ult. (Fac) Ax. Thrust kips	Ult. (Fac) Moment Cap in-kips	Bend. Stiff. at Ult Mom kip-in^2
1	0.65	98.240000	3284.	63.856000	2135.	7926581.
2	0.65	137.250000	3276.	89.212500	2129.	7970514.
1	0.75	98.240000	3284.	73.680000	2463.	7881402.
2	0.75	137.250000	3276.	102.937500	2457.	7916651.
1	0.90	98.240000	3284.	88.416000	2956.	7515122.
2	0.90	137.250000	3276.	123.525000	2948.	7570585.

Pile Section No. 2:

Dimensions and Properties of Drilled Shaft (Bored Pile):

Length of Section	=	5.500000 ft
Shaft Diameter	=	9.560000 in
Concrete Cover Thickness (to edge of long. rebar)	=	3.655000 in
Number of Reinforcing Bars	=	1 bar
Yield Stress of Reinforcing Bars	=	60000. psi
Modulus of Elasticity of Reinforcing Bars	=	29000000. psi
Gross Area of Shaft	=	71.780366 sq. in.
Total Area of Reinforcing Steel	=	2.250000 sq. in.
Area Ratio of Steel Reinforcement	=	3.13 percent
Edge-to-Edge Bar Spacing	=	-1.69300 in
Maximum Concrete Aggregate Size	=	0.375000 in
Ratio of Bar Spacing to Aggregate Size	=	-4.51
Offset of Center of Rebar Cage from Center of Pile	=	0.0000 in

Axial Structural Capacities:

Nom. Axial Structural Capacity = $0.85 F_c A_c + F_y A_s$	=	430.504 kips
Tensile Load for Cracking of Concrete	=	-39.723 kips
Nominal Axial Tensile Capacity	=	-135.000 kips

Reinforcing Bar Dimensions and Positions Used in Computations:

Bar	Bar Diam.	Bar Area	X	Y
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Number	inches	sq. in.	inches	inches
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1	1.693000	2.250000	0.00000	0.00000

NOTE: The positions of the above rebars were computed by LPILE

Concrete Properties:

Compressive Strength of Concrete	=	5000. psi
Modulus of Elasticity of Concrete	=	4030509. psi
Modulus of Rupture of Concrete	=	-530.33009 psi
Compression Strain at Peak Stress	=	0.002109
Tensile Strain at Fracture of Concrete	=	-0.0001150
Maximum Coarse Aggregate Size	=	0.375000 in

Number of Axial Thrust Force Values Determined from Pile-head Loadings = 2

Number	Axial Thrust Force kips
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1	98.240
2	137.250

Definitions of Run Messages and Notes:

- C = concrete in section has cracked in tension.
- Y = stress in reinforcing steel has reached yield stress.
- T = ACI 318 criteria for tension-controlled section met, tensile strain in reinforcement exceeds 0.005 while simultaneously compressive strain in concrete more than 0.003. See ACI 318-14, Section 21.2.3.
- Z = depth of tensile zone in concrete section is less than 10 percent of section depth.

Bending Stiffness (EI) = Computed Bending Moment / Curvature.
 Position of neutral axis is measured from edge of compression side of pile.
 Compressive stresses and strains are positive in sign.
 Tensile stresses and strains are negative in sign.

Axial Thrust Force = 98.240 kips

Bending Curvature rad/in.	Bending Moment in-kip	Bending Stiffness kip-in2	Depth to N Axis in	Max Comp Strain in/in	Max Tens Strain in/in	Max Conc Stress ksi	Max Steel Stress ksi	Run Msg
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0.00000125	2.1438388	1715071.	214.6743463	0.0002683	0.0002564	1.1912216	7.6381268	
0.00000250	4.2845614	1713825.	109.7295961	0.0002743	0.0002504	1.2156879	7.6677592	
0.00000375	6.4252560	1713402.	74.7490970	0.0002803	0.0002445	1.2400920	7.6975096	
0.00000500	8.5659087	1713182.	57.2596608	0.0002863	0.0002385	1.2644339	7.7273778	
0.00000625	10.7065053	1713041.	46.7666498	0.0002923	0.0002325	1.2887133	7.7573640	
0.00000750	12.8470318	1712938.	39.7718513	0.0002983	0.0002266	1.3129301	7.7874682	
0.00000875	14.9874742	1712854.	34.7760314	0.0003043	0.0002206	1.3370841	7.8176902	
0.00001000	17.1278184	1712782.	31.0295732	0.0003103	0.0002147	1.3611753	7.8480302	
0.00001125	19.2680504	1712716.	28.1160228	0.0003163	0.0002088	1.3852033	7.8784882	
0.00001250	21.4081561	1712652.	25.7855078	0.0003223	0.0002028	1.4091681	7.9090641	
0.00001375	23.5481214	1712591.	23.8790187	0.0003283	0.0001969	1.4330695	7.9397580	
0.00001500	25.6879324	1712529.	22.2905489	0.0003344	0.0001910	1.4569073	7.9705698	
0.00001625	27.8275749	1712466.	20.9467094	0.0003404	0.0001850	1.4806813	8.0014996	
0.00001750	29.9670350	1712402.	19.7950795	0.0003464	0.0001791	1.5043915	8.0325474	
0.00001875	32.1062985	1712336.	18.7972172	0.0003524	0.0001732	1.5280376	8.0637132	
0.00002000	34.2453513	1712268.	17.9242911	0.0003585	0.0001673	1.5516194	8.0949969	
0.00002125	36.3841796	1712197.	17.1542538	0.0003645	0.0001614	1.5751369	8.1263987	
0.00002250	38.5227690	1712123.	16.4699569	0.0003706	0.0001555	1.5985898	8.1579185	

0.00002375	40.6611057	1712047.	15.8578627	0.0003766	0.0001496	1.6219781	8.1895563
0.00002500	42.7991755	1711967.	15.3071408	0.0003827	0.0001437	1.6453014	8.2213121
0.00002625	44.9369644	1711884.	14.8090236	0.0003887	0.0001378	1.6685597	8.2531860
0.00002750	47.0744582	1711798.	14.3563379	0.0003948	0.0001319	1.6917528	8.2851780
0.00002875	49.2116430	1711709.	13.9431577	0.0004009	0.0001260	1.7148805	8.3172881
0.00003000	51.3485046	1711617.	13.5645450	0.0004069	0.0001201	1.7379427	8.3495162
0.00003125	53.4850290	1711521.	13.2163516	0.0004130	0.0001143	1.7609392	8.3818625
0.00003250	55.6212020	1711422.	12.8950676	0.0004191	0.0001084	1.7838699	8.4143268
0.00003375	57.7570097	1711319.	12.5977032	0.0004252	0.0001025	1.8067345	8.4469094
0.00003500	59.8924378	1711213.	12.3216955	0.0004313	0.00009666	1.8295329	8.4796100
0.00003625	62.0274723	1711103.	12.0648352	0.0004374	0.00009080	1.8522650	8.5124289
0.00003750	64.1620991	1710989.	11.8252076	0.0004434	0.00008495	1.8749306	8.5453659
0.00003875	66.2963042	1710872.	11.6011451	0.0004495	0.00007909	1.8975296	8.5784212
0.00004000	68.4300733	1710752.	11.3911884	0.0004556	0.00007325	1.9200616	8.6115947
0.00004125	70.5633924	1710628.	11.1940552	0.0004618	0.00006740	1.9425267	8.6448864
0.00004250	72.6962474	1710500.	11.0086140	0.0004679	0.00006157	1.9649246	8.6782964
0.00004375	74.8286242	1710369.	10.8338627	0.0004740	0.00005573	1.9872552	8.7118247
0.00004500	76.9605086	1710234.	10.6689105	0.0004801	0.00004990	2.0095183	8.7454713
0.00004625	79.0918866	1710095.	10.5129628	0.0004862	0.00004407	2.0317138	8.7792363
0.00004750	81.2227439	1709953.	10.3653088	0.0004924	0.00003825	2.0538414	8.8131196
0.00004875	83.3530664	1709806.	10.2253106	0.0004985	0.00003243	2.0759011	8.8471213
0.00005125	87.6120507	1709503.	9.9660407	0.0005108	0.00002081	2.1198157	8.9154799
0.00005375	91.8687263	1709186.	9.7311930	0.0005231	0.00000920	2.1634565	8.9843124
0.00005625	96.1229799	1708853.	9.5175111	0.0005354	-0.00000239	2.2068221	9.0536190
0.00005875	100.3744740	1708502.	9.3222910	0.0005477	-0.00001397	2.2499106	9.1233958
0.00006125	104.6220914	1708116.	9.1432617	0.0005600	-0.00002553	2.2927186	9.1936245
0.00006375	108.8643819	1707677.	8.9785045	0.0005724	-0.00003707	2.3352417	9.2642796
0.00006625	113.0998949	1707168.	8.8263898	0.0005847	-0.00004860	2.3774755	9.3353344
0.00006875	117.3272677	1706578.	8.6855253	0.0005971	-0.00006012	2.4194158	9.4067626
0.00007125	121.5452963	1705899.	8.5547152	0.0006095	-0.00007163	2.4610588	9.4785403
0.00007375	125.7528873	1705124.	8.4329265	0.0006219	-0.00008312	2.5024008	9.5506449
0.00007625	129.9490763	1704250.	8.3192624	0.0006343	-0.00009461	2.5434385	9.6230559
0.00007875	134.1330267	1703277.	8.2129412	0.0006468	-0.000106	2.5841691	9.6957549
0.00008125	134.1330267	1650868.	8.0544965	0.0006544	-0.000122	2.6089546	9.6302215 C
0.00008375	134.5242811	1606260.	7.9504209	0.0006658	-0.000135	2.6458658	9.6737623 C
0.00008625	137.2641648	1591469.	7.8514580	0.0006772	-0.000147	2.6822335	9.7150003 C
0.00008875	139.9078727	1576427.	7.7572042	0.0006885	-0.000160	2.7180718	9.7540087 C
0.00009125	142.4615066	1561222.	7.6673065	0.0006996	-0.000173	2.7533965	9.7908778 C
0.00009375	144.9313494	1545934.	7.5814560	0.0007108	-0.000185	2.7882246	9.8257149 C
0.00009625	147.3238087	1530637.	7.4993818	0.0007218	-0.000198	2.8225748	9.8586445 C
0.00009875	149.6326022	1515267.	7.4207021	0.0007328	-0.000211	2.8564228	9.8893941 C
0.0001013	151.8671327	1499922.	7.3452382	0.0007437	-0.000224	2.8897968	9.9181776 C
0.0001038	154.0395119	1484718.	7.2728692	0.0007546	-0.000237	2.9227371	9.9453308 C
0.0001063	156.1563166	1469707.	7.2034354	0.0007654	-0.000250	2.9552668	9.9710344 C
0.0001088	158.2071273	1454778.	7.1366040	0.0007761	-0.000264	2.9873467	9.9948775 C
0.0001113	160.1948403	1439954.	7.0722062	0.0007868	-0.000277	3.0189833	10.0168781 C
0.0001138	162.1423819	1425428.	7.0103220	0.0007974	-0.000290	3.0502630	10.0378371 C
0.0001163	164.0319697	1411028.	6.9505836	0.0008080	-0.000303	3.0811176	10.0570566 C
0.0001188	165.8706656	1396806.	6.8929114	0.0008185	-0.000317	3.1115707	10.0747295 C
0.0001213	167.6816066	1382941.	6.8374318	0.0008290	-0.000330	3.1417148	10.0917470 C
0.0001238	169.4227848	1369073.	6.7835272	0.0008395	-0.000344	3.1713802	10.1063752 C
0.0001263	171.1473575	1355623.	6.7316849	0.0008499	-0.000357	3.2007808	10.1207380 C
0.0001288	172.8126289	1342234.	6.6813016	0.0008602	-0.000371	3.2297418	10.1330301 C
0.0001313	174.4592581	1329213.	6.6327353	0.0008705	-0.000384	3.2584300	10.1449318 C
0.0001338	176.0539188	1316291.	6.5855061	0.0008808	-0.000398	3.2867064	10.1549789 C
0.0001363	177.6334191	1303732.	6.5399427	0.0008911	-0.000411	3.3147260	10.1647582 C
0.0001388	179.1602136	1291245.	6.4955267	0.0009013	-0.000425	3.3423274	10.1725500 C
0.0001413	180.6831214	1279173.	6.4527418	0.0009114	-0.000439	3.3697233	10.1805818 C
0.0001438	182.1448021	1267094.	6.4108447	0.0009216	-0.000453	3.3966592	10.1861103 C
0.0001463	183.6029998	1255405.	6.3704393	0.0009317	-0.000466	3.4233939	10.1918910 C
0.0001488	185.0206459	1243836.	6.3310208	0.0009417	-0.000480	3.4497579	10.1960691 C
0.0001588	190.4697018	1199809.	6.1842023	0.0009817	-0.000536	3.5523595	10.2056039 C
0.0001688	195.5671288	1158916.	6.0522624	0.0010213	-0.000592	3.6504002	10.2027959 C
0.0001788	200.3589637	1120889.	5.9329644	0.0010605	-0.000648	3.7441030	10.1889949 C
0.0001888	204.8986597	1085556.	5.8246943	0.0010994	-0.000705	3.8337377	10.1663652 C
0.0001988	209.2125117	1052642.	5.7259315	0.0011380	-0.000762	3.9194464	10.1357367 C
0.0002088	213.3257325	1021920.	5.6354656	0.0011764	-0.000819	4.0013688	10.0980525 C
0.0002188	217.2652779	993213.	5.5523627	0.0012146	-0.000877	4.0796580	10.0546079 C
0.0002288	221.0573832	966371.	5.4758839	0.0012526	-0.000934	4.1544657	10.0069057 C

0.0002388	224.7189449	941231.	5.4053396	0.0012905	-0.000992	4.2258926	9.9559348	C
0.0002488	228.2373331	917537.	5.3397872	0.0013283	-0.001050	4.2938667	9.9000587	C
0.0002588	231.6610695	895308.	5.2791821	0.0013660	-0.001108	4.3586651	9.8432860	C
0.0002688	234.9865956	874369.	5.2229197	0.0014037	-0.001166	4.4202729	9.7852072	C
0.0002788	238.2037557	854543.	5.1703560	0.0014412	-0.001224	4.4786262	9.7243962	C
0.0002888	241.3528452	835854.	5.1216060	0.0014789	-0.001282	4.5339571	9.6650332	C
0.0002988	244.3951670	818059.	5.0757633	0.0015164	-0.001340	4.5860395	9.6025776	C
0.0003088	247.3774943	801223.	5.0331403	0.0015540	-0.001398	4.6351361	9.5423702	C
0.0003188	250.2720703	785167.	4.9930530	0.0015915	-0.001456	4.6810816	9.4808795	C
0.0003288	253.0963405	769875.	4.9555005	0.0016291	-0.001514	4.7239715	9.4203036	C
0.0003388	255.8654863	755322.	4.9204600	0.0016668	-0.001572	4.7638684	9.3626237	C
0.0003488	258.5395451	741332.	4.8871596	0.0017044	-0.001630	4.8005636	9.3022193	C
0.0003588	261.1622577	727978.	4.8560562	0.0017421	-0.001688	4.8342674	9.2453583	C
0.0003688	263.7316859	715205.	4.8269585	0.0017799	-0.001745	4.8649453	9.1919049	C
0.0003788	266.2106997	702867.	4.7991658	0.0018177	-0.001803	4.8924253	9.1359089	C
0.0003888	268.6371822	691028.	4.7731297	0.0018556	-0.001861	4.9168605	-9.238502	C
0.0003988	271.0103107	679650.	4.7487229	0.0018936	-0.001918	4.9382199	-9.758383	C
0.0004088	273.3205720	668674.	4.7256901	0.0019316	-0.001976	4.9564465	-10.276132	C
0.0004188	275.5547513	658041.	4.7037301	0.0019697	-0.002034	4.9714912	-10.794213	C
0.0004288	277.7341811	647777.	4.6831096	0.0020079	-0.002091	4.9833969	-11.308375	C
0.0004388	279.8579684	637853.	4.6637423	0.0020462	-0.002148	4.9921297	-11.818552	C
0.0004488	281.9251945	628246.	4.6455495	0.0020847	-0.002205	4.9976547	-12.324677	C
0.0004588	283.9244117	618909.	4.6282702	0.0021232	-0.002262	4.9999347	-12.829201	C
0.0004688	285.8490155	609811.	4.6118611	0.0021618	-0.002319	4.9997693	-13.331918	C
0.0004788	287.7071999	600955.	4.5964764	0.0022006	-0.002376	4.9994170	-13.829930	C
0.0004888	289.4984070	592324.	4.5820581	0.0022395	-0.002433	4.9987780	-14.323167	C
0.0004988	291.2236287	583907.	4.5685474	0.0022786	-0.002489	4.9987731	-14.811640	C
0.0005088	292.8787729	575683.	4.5559088	0.0023178	-0.002546	4.9988885	-15.295082	C
0.0005188	294.4680464	567649.	4.5440804	0.0023572	-0.002602	4.9993289	-15.773666	C
0.0005288	295.9868822	559786.	4.5328015	0.0023967	-0.002658	4.9981321	-16.250684	C
0.0005388	297.4400700	552093.	4.5221770	0.0024363	-0.002714	4.9999389	-16.724020	C
0.0005488	298.8302339	544565.	4.5122508	0.0024761	-0.002770	4.9992241	-17.192408	C
0.0006088	306.0290569	502717.	4.4649304	0.0027180	-0.003102	4.9999957	-19.907606	C
0.0006688	311.4828485	465769.	4.4337518	0.0029651	-0.003428	4.9999460	-22.474411	C
0.0007288	315.5116476	432949.	4.4140133	0.0032167	-0.003750	4.9980420	-24.907955	C
0.0007888	318.3812208	403653.	4.4029241	0.0034728	-0.004068	4.9989132	-27.212347	C
0.0008488	320.2783803	377353.	4.3982062	0.0037330	-0.004381	4.9982621	-29.398507	C
0.0009088	320.2783803	352438.	4.4252020	0.0040214	-0.004666	4.9979947	-30.765314	C

Axial Thrust Force = 137.250 kips

Bending Curvature rad/in.	Bending Moment in-kip	Bending Stiffness kip-in2	Depth to N Axis in	Max Comp Strain in/in	Max Tens Strain in/in	Max Conc Stress ksi	Max Steel Stress ksi	Run Msg
0.00000125	2.0150451	1612036.	305.1077180	0.0003814	0.0003694	1.6446853	10.9163365	
0.00000250	4.0256137	1610245.	154.9464091	0.0003874	0.0003635	1.6676477	10.9459782	
0.00000375	6.0361529	1609641.	104.8937808	0.0003934	0.0003575	1.6905479	10.9757439	
0.00000500	8.0466479	1609330.	79.8683227	0.0003993	0.0003515	1.7133855	11.0056338	
0.00000625	10.0570839	1609133.	64.8537327	0.0004053	0.0003456	1.7361604	11.0356477	
0.00000750	12.0674461	1608993.	54.8445768	0.0004113	0.0003396	1.7588726	11.0657858	
0.00000875	14.0777198	1608882.	47.6956689	0.0004173	0.0003337	1.7815217	11.0960481	
0.00001000	16.0878901	1608789.	42.3344160	0.0004233	0.0003277	1.8041076	11.1264345	
0.00001125	18.0979423	1608706.	38.1649332	0.0004294	0.0003218	1.8266301	11.1569451	
0.00001250	20.1078616	1608629.	34.8296895	0.0004354	0.0003159	1.8490892	11.1875798	
0.00001375	22.1176332	1608555.	32.1011651	0.0004414	0.0003099	1.8714845	11.2183387	
0.00001500	24.1272422	1608483.	29.8276801	0.0004474	0.0003040	1.8938160	11.2492218	
0.00001625	26.1366740	1608411.	27.9042256	0.0004534	0.0002981	1.9160834	11.2802290	
0.00001750	28.1459137	1608338.	26.2557951	0.0004595	0.0002922	1.9382866	11.3113604	
0.00001875	30.1549465	1608264.	24.8273836	0.0004655	0.0002863	1.9604254	11.3426161	
0.00002000	32.1637576	1608188.	23.5777378	0.0004716	0.0002804	1.9824997	11.3739959	
0.00002125	34.1723322	1608110.	22.4753107	0.0004776	0.0002745	2.0045092	11.4054999	
0.00002250	36.1806556	1608029.	21.4955658	0.0004837	0.0002686	2.0264539	11.4371282	
0.00002375	38.1887128	1607946.	20.6191324	0.0004897	0.0002627	2.0483335	11.4688807	
0.00002500	40.1964891	1607860.	19.8305137	0.0004958	0.0002568	2.0701478	11.5007575	
0.00002625	42.2039697	1607770.	19.1171648	0.0005018	0.0002509	2.0918967	11.5327586	
0.00002750	44.2111398	1607678.	18.4688217	0.0005079	0.0002450	2.1135801	11.5648839	
0.00002875	46.2179845	1607582.	17.8770053	0.0005140	0.0002391	2.1351976	11.5971335	

0.00003000	48.2244890	1607483.	17.3346498	0.0005200	0.0002332	2.1567493	11.6295074
0.00003125	50.2306386	1607380.	16.8358200	0.0005261	0.0002274	2.1782349	11.6620057
0.00003250	52.2364183	1607274.	16.3754936	0.0005322	0.0002215	2.1996541	11.6946283
0.00003375	54.2418133	1607165.	15.9493926	0.0005383	0.0002156	2.2210070	11.7273753
0.00003500	56.2468089	1607052.	15.5538499	0.0005444	0.0002098	2.2422932	11.7602467
0.00003625	58.2513901	1606935.	15.1857044	0.0005505	0.0002039	2.2635126	11.7932426
0.00003750	60.2555422	1606814.	14.8422163	0.0005566	0.0001981	2.2846651	11.8263628
0.00003875	62.2592502	1606690.	14.5209995	0.0005627	0.0001922	2.3057505	11.8596075
0.00004000	64.2624994	1606562.	14.2199660	0.0005688	0.0001864	2.3267685	11.8929767
0.00004125	66.2652748	1606431.	13.9372811	0.0005749	0.0001806	2.3477191	11.9264704
0.00004250	68.2675616	1606296.	13.6713257	0.0005810	0.0001747	2.3686020	11.9600886
0.00004375	70.2693449	1606156.	13.4206660	0.0005872	0.0001689	2.3894171	11.9938314
0.00004500	72.2706100	1606014.	13.1840273	0.0005933	0.0001631	2.4101642	12.0276987
0.00004625	74.2713417	1605867.	12.9602727	0.0005994	0.0001573	2.4308432	12.0616906
0.00004750	76.2715255	1605716.	12.7483852	0.0006055	0.0001514	2.4514538	12.0958072
0.00004875	78.2711462	1605562.	12.5474519	0.0006117	0.0001456	2.4719958	12.1300485
0.00005125	82.2686391	1605242.	12.1752418	0.0006240	0.0001340	2.5128738	12.1989050
0.00005375	86.2637012	1604906.	11.8379761	0.0006363	0.0001224	2.5534756	12.2682606
0.00005625	90.2562134	1604555.	11.5309955	0.0006486	0.0001109	2.5937999	12.3381154
0.00005875	94.2460560	1604188.	11.2504342	0.0006610	0.00009931	2.6338453	12.4084697
0.00006125	98.2331097	1603806.	10.9930572	0.0006733	0.00008777	2.6736104	12.4793238
0.00006375	102.2172547	1603408.	10.7561371	0.0006857	0.00007625	2.7130939	12.5506780
0.00006625	106.1983713	1602994.	10.5373583	0.0006981	0.00006475	2.7522942	12.6225325
0.00006875	110.1763397	1602565.	10.3347417	0.0007105	0.00005326	2.7912101	12.6948877
0.00007125	114.1510398	1602120.	10.1465863	0.0007229	0.00004179	2.8298402	12.7677440
0.00007375	118.1223515	1601659.	9.9714217	0.0007354	0.00003034	2.8681829	12.8411015
0.00007625	122.0901545	1601182.	9.8079701	0.0007479	0.00001891	2.9062370	12.9149608
0.00007875	126.0543284	1600690.	9.6551162	0.0007603	0.00000749	2.9440011	12.9893221
0.00008125	130.0147527	1600182.	9.5118820	0.0007728	-0.00000391	2.9814736	13.0641859
0.00008375	133.9711262	1599655.	9.3774046	0.0007854	-0.00001529	3.0186529	13.1395490
0.00008625	137.9226983	1599104.	9.2509179	0.0007979	-0.00002666	3.0555364	13.2153994
0.00008875	141.8685306	1598519.	9.1317402	0.0008104	-0.00003801	3.0921208	13.2917209
0.00009125	145.8076291	1597892.	9.0192641	0.0008230	-0.00004934	3.1284032	13.3684956
0.00009375	149.7390160	1597216.	8.9129466	0.0008356	-0.00006066	3.1643803	13.4457052
0.00009625	153.6617709	1596486.	8.8123016	0.0008482	-0.00007197	3.2000492	13.5233320
0.00009875	157.5750299	1595697.	8.7168923	0.0008608	-0.00008326	3.2354071	13.6013589
0.0001013	161.4779909	1594844.	8.6263253	0.0008734	-0.00009453	3.2704511	13.6797698
0.0001038	165.3699131	1593927.	8.5402456	0.0008861	-0.000106	3.3051787	13.7585494
0.0001063	165.3699131	1556423.	8.4275831	0.0008954	-0.000120	3.3306483	13.7429394 C
0.0001088	167.8457962	1543410.	8.3436607	0.0009074	-0.000132	3.3628844	13.8016325 C
0.0001113	170.7310084	1534661.	8.2630238	0.0009193	-0.000144	3.3946608	13.8587566 C
0.0001138	173.5266546	1525509.	8.1853683	0.0009311	-0.000156	3.4259554	13.9140233 C
0.0001163	176.2401327	1516044.	8.1105405	0.0009429	-0.000168	3.4567850	13.9675628 C
0.0001188	178.8847896	1506398.	8.0384551	0.0009546	-0.000181	3.4871833	14.0196963 C
0.0001213	181.4667908	1496633.	7.9689828	0.0009662	-0.000193	3.5171667	14.0705659 C
0.0001238	183.9726246	1486647.	7.9018427	0.0009779	-0.000205	3.5466997	14.1197317 C
0.0001263	186.4060520	1476484.	7.8369077	0.0009894	-0.000218	3.5757907	14.1672355 C
0.0001288	188.7911619	1466339.	7.7742376	0.0010009	-0.000230	3.6045047	14.2137802 C
0.0001313	191.1093657	1456071.	7.7135427	0.0010124	-0.000242	3.6327922	14.2587561 C
0.0001338	193.3640490	1445713.	7.6547226	0.0010238	-0.000255	3.6606606	14.3022031 C
0.0001363	195.5854049	1435489.	7.5979200	0.0010352	-0.000267	3.6881954	14.3450927 C
0.0001388	197.7234545	1425034.	7.5425998	0.0010465	-0.000280	3.7152560	14.3857108 C
0.0001413	199.8334747	1414750.	7.4891296	0.0010578	-0.000293	3.7419979	14.4258826 C
0.0001438	201.8821780	1404398.	7.4371329	0.0010691	-0.000305	3.7683284	14.4644493 C
0.0001463	203.8917033	1394131.	7.3867053	0.0010803	-0.000318	3.7943091	14.5021290 C
0.0001488	205.8533199	1383888.	7.3376930	0.0010915	-0.000331	3.8199168	14.5385991 C
0.0001588	213.2862301	1343535.	7.1548179	0.0011358	-0.000382	3.9188080	14.6740757 C
0.0001688	220.1291764	1304469.	6.9905174	0.0011796	-0.000434	4.0122701	14.7943806 C
0.0001788	226.4758624	1266998.	6.8421314	0.0012230	-0.000486	4.1006208	14.9018889 C
0.0001888	232.3499597	1230993.	6.7070538	0.0012660	-0.000538	4.1839600	14.9961807 C
0.0001988	237.8462178	1196711.	6.5838373	0.0013085	-0.000592	4.2626213	15.0804903 C
0.0002088	243.0055598	1164098.	6.4709553	0.0013508	-0.000645	4.3367668	15.1558982 C
0.0002188	247.8564722	1133058.	6.3670889	0.0013928	-0.000698	4.4065182	15.2230272 C
0.0002288	252.4268424	1103505.	6.2711663	0.0014345	-0.000752	4.4719944	15.2826102 C
0.0002388	256.7437634	1075367.	6.1823113	0.0014760	-0.000806	4.5333098	15.3354921 C
0.0002488	260.8333687	1048576.	6.0998054	0.0015173	-0.000861	4.5905738	15.3826397 C
0.0002588	264.7206659	1023075.	6.0230588	0.0015585	-0.000915	4.6438886	15.4251501 C
0.0002688	268.4293697	998807.	5.9515875	0.0015995	-0.000970	4.6933483	15.4642623 C
0.0002788	271.9700299	975677.	5.8848804	0.0016404	-0.001024	4.7390019	15.5004329 C

0.0002888	275.3168364	953478.	5.8221311	0.0016811	-0.001079	4.7807880	15.5310555 C
0.0002988	278.5391227	932349.	5.7635510	0.0017219	-0.001134	4.8189225	15.5614042 C
0.0003088	281.6113946	912102.	5.7084776	0.0017625	-0.001189	4.8533436	15.5891743 C
0.0003188	284.5451136	892691.	5.6566403	0.0018031	-0.001244	4.8840890	15.6149162 C
0.0003288	287.3660013	874117.	5.6079930	0.0018436	-0.001299	4.9112294	15.6410045 C
0.0003388	290.0525714	856244.	5.5620022	0.0018841	-0.001354	4.9347155	15.6649748 C
0.0003488	292.6376320	839104.	5.5187698	0.0019247	-0.001409	4.9546191	15.6901677 C
0.0003588	295.1144381	822619.	5.4779757	0.0019652	-0.001464	4.9709172	15.7156525 C
0.0003688	297.4782788	806721.	5.4393718	0.0020058	-0.001519	4.9836020	15.7408998 C
0.0003788	299.7709327	791474.	5.4032303	0.0020465	-0.001574	4.9927065	15.7708019 C
0.0003888	301.9280117	776664.	5.3686514	0.0020871	-0.001629	4.9981620	15.7973594 C
0.0003988	304.0096692	762407.	5.3361806	0.0021278	-0.001684	5.0000000	15.8282376 C
0.0004088	306.0095928	748647.	5.3057364	0.0021687	-0.001739	4.9994722	15.8643085 C
0.0004188	307.8689907	735210.	5.2765450	0.0022096	-0.001794	4.9997531	15.8979223 C
0.0004288	309.6422225	722198.	5.2491631	0.0022506	-0.001848	4.9999964	15.9371186 C
0.0004388	311.3295963	709583.	5.2234694	0.0022918	-0.001903	4.9999613	15.9819135 C
0.0004488	312.9138793	697301.	5.1990922	0.0023331	-0.001957	4.9998441	16.0289360 C
0.0004588	314.3955822	685331.	5.1758928	0.0023744	-0.002011	4.9995707	16.0774879 C
0.0004688	315.8012727	673709.	5.1540769	0.0024160	-0.002065	4.9990522	16.1313907 C
0.0004788	317.1343968	662422.	5.1335478	0.0024577	-0.002119	4.9981777	16.1905055 C
0.0004888	318.3930377	651444.	5.1142261	0.0024996	-0.002173	4.9999526	16.2548257 C
0.0004988	319.5505495	640703.	5.0956019	0.0025414	-0.002227	4.9995299	16.3180299 C
0.0005088	320.6462575	630263.	5.0780380	0.0025835	-0.002280	4.9985311	16.3860767 C
0.0005188	321.6810383	620108.	5.0614720	0.0026256	-0.002334	4.9999820	16.4589458 C
0.0005288	322.6498176	610212.	5.0458715	0.0026680	-0.002387	4.9994450	16.5370117 C
0.0005388	323.5662858	600587.	5.0311306	0.0027105	-0.002440	4.9979980	16.6194603 C
0.0005488	324.4224325	591203.	5.0171796	0.0027532	-0.002493	4.9998515	16.7059301 C
0.0006088	328.4304903	539516.	4.9466249	0.0030113	-0.002808	4.9998682	17.2869936 C
0.0006688	330.9088209	494817.	4.8953822	0.0032738	-0.003119	4.9996406	17.9970569 C
0.0007288	332.2026062	455853.	4.8580555	0.0035403	-0.003427	4.9985858	18.8228928 C
0.0007888	332.5496836	421616.	4.8313919	0.0038108	-0.003730	4.9976742	19.7627371 C

Summary of Results for Nominal Moment Capacity for Section 2

Moment values interpolated at maximum compressive strain = 0.003
or maximum developed moment if pile fails at smaller strains.

Load No.	Axial Thrust kips	Nominal Mom. Cap. in-kip	Max. Comp. Strain	Max. Tens. Strain
1	98.240	312.042	0.00300000	-0.00347287
2	137.250	328.256	0.00300000	-0.00279463

Note that the values of moment capacity in the table above are not factored by a strength reduction factor (ϕ -factor).

In ACI 318, the value of the strength reduction factor depends on whether the transverse reinforcing steel bars are tied hoops (0.65) or spirals (0.75).

The above values should be multiplied by the appropriate strength reduction factor to compute ultimate moment capacity according to ACI 318, or the value required by the design standard being followed.

The following table presents factored moment capacities and corresponding bending stiffnesses computed for common resistance factor values used for reinforced concrete sections.

Axial Load No.	Resist. Factor	Nominal Ax. Thrust kips	Nominal Moment Cap in-kips	Ult. (Fac) Ax. Thrust kips	Ult. (Fac) Moment Cap in-kips	Bend. Stiff. at Ult Mom kip-in ²
1	0.65	98.240000	312.042058	63.856000	202.827338	1101677.
2	0.65	137.250000	328.255652	89.212500	213.366174	1343079.
1	0.75	98.240000	312.042058	73.680000	234.031544	880382.
2	0.75	137.250000	328.255652	102.937500	246.191739	1143711.

1	0.90	98.240000	312.042058	88.416000	280.837853	633299.
2	0.90	137.250000	328.255652	123.525000	295.430087	820496.

Layering Correction Equivalent Depths of Soil & Rock Layers

Layer No.	Top of Layer Below Pile Head ft	Equivalent Top Depth Below Grnd Surf ft	Same Layer Type As Layer Above	Layer is Rock or is Below Rock Layer	F0 Integral for Layer lbs	F1 Integral for Layer lbs
1	0.00	0.00	N.A.	No	0.00	81556.
2	13.0000	13.0000	No	Yes	N.A.	N.A.

Notes: The F0 integral of Layer n+1 equals the sum of the F0 and F1 integrals for Layer n. Layering correction equivalent depths are computed only for soil types with both shallow-depth and deep-depth expressions for peak lateral load transfer. These soil types are soft and stiff clays, non-liquefied sands, and cemented c-phi soil.

Computed Values of Pile Loading and Deflection
for Lateral Loading for Load Case Number 1

Pile-head conditions are Shear and Pile-head Rotation (Loading Type 2)

Shear force at pile head = 5180.0 lbs
Rotation of pile head = 0.000E+00 radians
Axial load at pile head = 137250.0 lbs

(Zero slope for this load indicates fixed-head conditions)

Depth X feet	Deflect. y inches	Bending Moment in-lbs	Shear Force lbs	Slope S radians	Total Stress psi*	Bending Stiffness lb-in^2	Soil Res. p lb/inch	Soil Spr. Es*H lb/inch	Distrib. Lat. Load lb/inch
0.00	0.09593	-274164.	5180.	0.00	0.00	8.94E+09	0.00	0.00	0.00
0.1950	0.09585	-262031.	5176.	-7.02E-05	0.00	8.94E+09	-3.725	90.9324	0.00
0.3900	0.09560	-249896.	5162.	-1.37E-04	0.00	8.94E+09	-7.606	186.1704	0.00
0.5850	0.09521	-237783.	5140.	-2.01E-04	0.00	8.94E+09	-11.362	279.2556	0.00
0.7800	0.09466	-225711.	5109.	-2.62E-04	0.00	8.94E+09	-15.063	372.3408	0.00
0.9750	0.09398	-213703.	5070.	-3.19E-04	0.00	8.94E+09	-18.693	465.4260	0.00
1.1700	0.09317	-201780.	5022.	-3.74E-04	0.00	8.94E+09	-22.238	558.5112	0.00
1.3650	0.09223	-189961.	4966.	-4.25E-04	0.00	8.94E+09	-25.684	651.5964	0.00
1.5600	0.09118	-178267.	4902.	-4.73E-04	0.00	8.94E+09	-29.018	744.6816	0.00
1.7550	0.09002	-166717.	4830.	-5.18E-04	0.00	8.94E+09	-32.229	837.7668	0.00
1.9500	0.08876	-155329.	4751.	-5.60E-04	0.00	8.94E+09	-35.307	930.8520	0.00
2.1450	0.08740	-144121.	4665.	-6.00E-04	0.00	8.94E+09	-38.244	1024.	0.00
2.3400	0.08595	-133111.	4572.	-6.36E-04	0.00	8.94E+09	-41.030	1117.	0.00
2.5350	0.08442	-122314.	4474.	-6.69E-04	0.00	8.94E+09	-42.948	1190.	0.00
2.7300	0.08282	-111742.	4373.	-7.00E-04	0.00	8.94E+09	-43.647	1233.	0.00
2.9250	0.08115	-101400.	4269.	-7.28E-04	0.00	8.94E+09	-44.899	1295.	0.00
3.1200	0.07941	-91295.	4163.	-7.53E-04	0.00	8.94E+09	-45.506	1341.	0.00
3.3150	0.07762	-81432.	4057.	-7.76E-04	0.00	8.94E+09	-45.411	1369.	0.00
3.5100	0.07578	-71810.	3952.	-7.96E-04	0.00	8.94E+09	-44.565	1376.	0.00
3.7050	0.07390	-62426.	3846.	-8.13E-04	0.00	8.94E+09	-45.661	1446.	0.00
3.9000	0.07198	-53288.	3736.	-8.28E-04	0.00	8.94E+09	-48.145	1565.	0.00
4.0950	0.07002	-44408.	3621.	-8.41E-04	0.00	8.94E+09	-50.482	1687.	0.00
4.2900	0.06804	-35801.	3500.	-8.52E-04	0.00	8.94E+09	-52.651	1811.	0.00
4.4850	0.06604	-27479.	3375.	-8.60E-04	0.00	8.94E+09	-54.673	1937.	0.00

4.6800	0.06402	-19454.	3243.	-8.66E-04	0.00	8.94E+09	-57.886	2116.	0.00
4.8750	0.06198	-11745.	3104.	-8.70E-04	0.00	8.94E+09	-61.071	2306.	0.00
5.0700	0.05994	-4369.	2960.	-8.72E-04	0.00	8.94E+09	-61.999	2420.	0.00
5.2650	0.05790	2668.	2815.	-8.72E-04	0.00	8.94E+09	-62.190	2513.	0.00
5.4600	0.05586	9364.	2669.	-8.71E-04	0.00	8.94E+09	-62.220	2606.	0.00
5.6550	0.05383	15719.	2524.	-8.68E-04	0.00	8.94E+09	-62.095	2699.	0.00
5.8500	0.05180	21732.	2379.	-8.63E-04	0.00	8.94E+09	-61.819	2793.	0.00
6.0450	0.04979	27405.	2234.	-8.56E-04	0.00	8.94E+09	-61.398	2886.	0.00
6.2400	0.04779	32739.	2091.	-8.48E-04	0.00	8.94E+09	-60.838	2979.	0.00
6.4350	0.04582	37738.	1950.	-8.39E-04	0.00	8.94E+09	-60.147	3072.	0.00
6.6300	0.04387	42404.	1810.	-8.29E-04	0.00	8.94E+09	-59.329	3165.	0.00
6.8250	0.04194	46742.	1672.	-8.17E-04	0.00	8.94E+09	-58.392	3258.	0.00
7.0200	0.04004	50756.	1537.	-8.04E-04	0.00	8.94E+09	-57.343	3351.	0.00
7.2150	0.03818	54452.	1404.	-7.91E-04	0.00	8.94E+09	-56.189	3444.	0.00
7.4100	0.03634	57835.	1274.	-7.76E-04	0.00	8.94E+09	-54.936	3537.	0.00
7.6050	0.03454	60913.	1147.	-7.60E-04	0.00	8.94E+09	-53.593	3630.	0.00
7.8000	0.03278	63692.	1023.	-7.44E-04	0.00	8.94E+09	-52.166	3723.	0.00
7.9950	0.03106	66180.	903.1252	-7.27E-04	0.00	8.94E+09	-50.663	3816.	0.00
8.1900	0.02938	68386.	786.4148	-7.09E-04	0.00	8.94E+09	-49.090	3910.	0.00
8.3850	0.02774	70317.	673.4571	-6.91E-04	0.00	8.94E+09	-47.455	4003.	0.00
8.5800	0.02615	71982.	564.3888	-6.73E-04	0.00	8.94E+09	-45.765	4096.	0.00
8.7750	0.02460	73390.	459.3307	-6.54E-04	0.00	8.94E+09	-44.028	4189.	0.00
8.9700	0.02309	74551.	358.3872	-6.34E-04	0.00	8.94E+09	-42.249	4282.	0.00
9.1650	0.02163	75475.	261.6468	-6.15E-04	0.00	8.94E+09	-40.435	4375.	0.00
9.3600	0.02021	76170.	169.1827	-5.95E-04	0.00	8.94E+09	-38.594	4468.	0.00
9.5550	0.01884	76648.	81.0530	-5.75E-04	0.00	8.94E+09	-36.731	4561.	0.00
9.7500	0.01752	76919.	-2.699	-5.55E-04	0.00	8.94E+09	-34.852	4654.	0.00
9.9450	0.01625	76992.	-82.044	-5.34E-04	0.00	8.94E+09	-32.964	4747.	0.00
10.1400	0.01502	76878.	-156.966	-5.14E-04	0.00	8.94E+09	-31.072	4840.	0.00
10.3350	0.01384	76588.	-227.464	-4.94E-04	0.00	8.94E+09	-29.182	4934.	0.00
10.5300	0.01271	76131.	-293.545	-4.74E-04	0.00	8.94E+09	-27.298	5027.	0.00
10.7250	0.01162	75519.	-355.234	-4.54E-04	0.00	8.94E+09	-25.427	5120.	0.00
10.9200	0.01058	74760.	-412.562	-4.35E-04	0.00	8.94E+09	-23.572	5213.	0.00
11.1150	0.00959	73867.	-465.575	-4.15E-04	0.00	8.94E+09	-21.738	5306.	0.00
11.3100	0.00864	72848.	-514.326	-3.96E-04	0.00	8.94E+09	-19.929	5399.	0.00
11.5050	0.00773	71714.	-558.879	-3.77E-04	0.00	8.94E+09	-18.150	5492.	0.00
11.7000	0.00687	70475.	-599.307	-3.59E-04	0.00	8.94E+09	-16.404	5585.	0.00
11.8950	0.00606	69140.	-635.691	-3.40E-04	0.00	8.94E+09	-14.693	5678.	0.00
12.0900	0.00528	67719.	-668.118	-3.22E-04	0.00	8.94E+09	-13.023	5771.	0.00
12.2850	0.00455	66220.	-696.685	-3.05E-04	0.00	8.94E+09	-11.394	5864.	0.00
12.4800	0.00385	64654.	-721.494	-2.88E-04	0.00	8.94E+09	-9.810	5957.	0.00
12.6750	0.00320	63028.	-742.653	-2.71E-04	0.00	8.94E+09	-8.274	6051.	0.00
12.8700	0.00259	61352.	-760.274	-2.55E-04	0.00	8.94E+09	-6.787	6144.	0.00
13.0650	0.00201	59634.	-1113.	-2.39E-04	0.00	8.94E+09	-294.746	343525.	0.00
13.2600	0.00147	56297.	-1711.	-2.24E-04	0.00	8.94E+09	-216.678	345629.	0.00
13.4550	9.61E-04	51768.	-2132.	-2.10E-04	0.00	8.94E+09	-142.708	347603.	0.00
13.6500	4.86E-04	46454.	-2384.	-1.97E-04	0.00	8.94E+09	-72.596	349457.	0.00
13.8450	4.00E-05	40738.	-2476.	-1.85E-04	0.00	8.94E+09	-6.002	351202.	0.00
14.0400	-3.81E-04	34986.	-2441.	-1.55E-04	0.00	1.61E+09	35.6456	218824.	0.00
14.2350	-6.83E-04	29413.	-2325.	-1.08E-04	0.00	1.61E+09	63.7427	218317.	0.00
14.4300	-8.85E-04	24175.	-2154.	-6.87E-05	0.00	1.61E+09	82.4537	217985.	0.00
14.6250	-0.00100	19378.	-1948.	-3.70E-05	0.00	1.61E+09	93.5129	217793.	0.00
14.8200	-0.00106	15083.	-1723.	-1.20E-05	0.00	1.61E+09	98.4689	217712.	0.00
15.0150	-0.00106	11320.	-1493.	7.25E-06	0.00	1.61E+09	98.6854	217716.	0.00
15.2100	-0.00102	8093.	-1266.	2.14E-05	0.00	1.61E+09	95.3451	217783.	0.00
15.4050	-9.61E-04	5384.	-1049.	3.12E-05	0.00	1.61E+09	89.4575	217894.	0.00
15.6000	-8.79E-04	3162.	-848.908	3.74E-05	0.00	1.61E+09	81.8685	218035.	0.00
15.7950	-7.86E-04	1387.	-667.393	4.07E-05	0.00	1.61E+09	73.2729	218191.	0.00
15.9900	-6.88E-04	12.4518	-506.517	4.17E-05	0.00	1.61E+09	64.2273	218354.	0.00
16.1850	-5.91E-04	-1010.	-366.830	4.10E-05	0.00	1.61E+09	55.1639	218516.	0.00
16.3800	-4.97E-04	-1731.	-247.993	3.90E-05	0.00	1.61E+09	46.4062	218671.	0.00
16.5750	-4.08E-04	-2196.	-149.022	3.61E-05	0.00	1.61E+09	38.1840	218816.	0.00
16.7700	-3.28E-04	-2451.	-68.490	3.27E-05	0.00	1.61E+09	30.6471	218948.	0.00
16.9650	-2.55E-04	-2538.	-4.694	2.91E-05	0.00	1.61E+09	23.8794	219065.	0.00
17.1600	-1.91E-04	-2492.	44.2010	2.55E-05	0.00	1.61E+09	17.9110	219169.	0.00
17.3550	-1.36E-04	-2347.	80.0505	2.20E-05	0.00	1.61E+09	12.7296	219257.	0.00
17.5500	-8.85E-05	-2131.	104.6446	1.87E-05	0.00	1.61E+09	8.2910	219333.	0.00
17.7450	-4.83E-05	-1869.	119.6429	1.58E-05	0.00	1.61E+09	4.5280	219397.	0.00
17.9400	-1.45E-05	-1582.	126.5299	1.33E-05	0.00	1.61E+09	1.3583	219450.	0.00

18.1350	1.40E-05	-1286.	126.5880	1.12E-05	0.00	1.61E+09	-1.309	219451.	0.00
18.3300	3.80E-05	-996.392	120.8852	9.56E-06	0.00	1.61E+09	-3.566	219414.	0.00
18.5250	5.87E-05	-726.122	110.2734	8.31E-06	0.00	1.61E+09	-5.504	219382.	0.00
18.7200	7.69E-05	-485.653	95.3955	7.43E-06	0.00	1.61E+09	-7.212	219354.	0.00
18.9150	9.35E-05	-284.446	76.7039	6.87E-06	0.00	1.61E+09	-8.764	219329.	0.00
19.1100	1.09E-04	-131.095	54.4861	6.57E-06	0.00	1.61E+09	-10.226	219306.	0.00
19.3050	1.24E-04	-33.673	28.8974	6.45E-06	0.00	1.61E+09	-11.645	219283.	0.00
19.5000	1.39E-04	0.00	0.00	6.43E-06	0.00	1.61E+09	-13.054	109630.	0.00

* This analysis computed pile response using nonlinear moment-curvature relationships. Values of total stress due to combined axial and bending stresses are computed only for elastic sections only and do not equal the actual stresses in concrete and steel. Stresses in concrete and steel may be interpolated from the output for nonlinear bending properties relative to the magnitude of bending moment developed in the pile.

Output Summary for Load Case No. 1:

Pile-head deflection = 0.09593309 inches
 Computed slope at pile head = 0.000000 radians
 Maximum bending moment = -274164. inch-lbs
 Maximum shear force = 5180. lbs
 Depth of maximum bending moment = 0.000000 feet below pile head
 Depth of maximum shear force = 0.000000 feet below pile head
 Number of iterations = 6
 Number of zero deflection points = 2

 Pile-head Deflection vs. Pile Length for Load Case 1

Boundary Condition Type 2, Shear and Slope

Shear = 5180. lbs
 Slope = 0.00000
 Axial Load = 137250. lbs

Pile Length feet	Pile Head Deflection inches	Maximum Moment ln-lbs	Maximum Shear lbs
19.50000	0.09593309	-274164.	5180.
18.52500	0.09603322	-273979.	5180.
17.55000	0.09612643	-273935.	5180.
16.57500	0.09592540	-274077.	5180.
15.60000	0.09649954	-273847.	5180.
14.62500	0.09892822	-273780.	5180.
13.65000	0.10282492	-275163.	5180.
12.67500	0.11507249	-303052.	5180.
11.70000	0.11853955	-314724.	5180.
10.72500	0.12017543	-324442.	5180.
9.75000	0.11994941	-328397.	5180.
8.77500	0.11970190	-323506.	5180.
7.80000	0.12405927	-308975.	5180.
6.82500	0.14428745	-285700.	5180.
5.85000	0.22946199	-249183.	5180.

 Computed Values of Pile Loading and Deflection
 for Lateral Loading for Load Case Number 2

Pile-head conditions are Shear and Pile-head Rotation (Loading Type 2)

Shear force at pile head = 0.0 lbs
 Rotation of pile head = 0.000E+00 radians
 Axial load at pile head = 98240.0 lbs

(Zero slope for this load indicates fixed-head conditions)

Depth X feet	Deflect. y inches	Bending Moment in-lbs	Shear Force lbs	Slope S radians	Total Stress psi*	Bending Stiffness lb-in^2	Soil Res. p lb/inch	Soil Spr. Es*H lb/inch	Distrib. Lat. Load lb/inch
0.00	0.00	0.00	0.00	0.00	0.00	8.98E+09	0.00	0.00	0.00
0.1950	0.00	0.00	0.00	0.00	0.00	8.98E+09	0.00	109.5120	0.00
0.3900	0.00	0.00	0.00	0.00	0.00	8.98E+09	0.00	219.0240	0.00
0.5850	0.00	0.00	0.00	0.00	0.00	8.98E+09	0.00	328.5360	0.00
0.7800	0.00	0.00	0.00	0.00	0.00	8.98E+09	0.00	438.0480	0.00
0.9750	0.00	0.00	0.00	0.00	0.00	8.98E+09	0.00	547.5600	0.00
1.1700	0.00	0.00	0.00	0.00	0.00	8.98E+09	0.00	657.0720	0.00
1.3650	0.00	0.00	0.00	0.00	0.00	8.98E+09	0.00	766.5840	0.00
1.5600	0.00	0.00	0.00	0.00	0.00	8.98E+09	0.00	876.0960	0.00
1.7550	0.00	0.00	0.00	0.00	0.00	8.98E+09	0.00	985.6080	0.00
1.9500	0.00	0.00	0.00	0.00	0.00	8.98E+09	0.00	1095.	0.00
2.1450	0.00	0.00	0.00	0.00	0.00	8.98E+09	0.00	1205.	0.00
2.3400	0.00	0.00	0.00	0.00	0.00	8.98E+09	0.00	1314.	0.00
2.5350	0.00	0.00	0.00	0.00	0.00	8.98E+09	0.00	1424.	0.00
2.7300	0.00	0.00	0.00	0.00	0.00	8.98E+09	0.00	1533.	0.00
2.9250	0.00	0.00	0.00	0.00	0.00	8.98E+09	0.00	1643.	0.00
3.1200	0.00	0.00	0.00	0.00	0.00	8.98E+09	0.00	1752.	0.00
3.3150	0.00	0.00	0.00	0.00	0.00	8.98E+09	0.00	1862.	0.00
3.5100	0.00	0.00	0.00	0.00	0.00	8.98E+09	0.00	1971.	0.00
3.7050	0.00	0.00	0.00	0.00	0.00	8.98E+09	0.00	2081.	0.00
3.9000	0.00	0.00	0.00	0.00	0.00	8.98E+09	0.00	2190.	0.00
4.0950	0.00	0.00	0.00	0.00	0.00	8.98E+09	0.00	2300.	0.00
4.2900	0.00	0.00	0.00	0.00	0.00	8.98E+09	0.00	2409.	0.00
4.4850	0.00	0.00	0.00	0.00	0.00	8.98E+09	0.00	2519.	0.00
4.6800	0.00	0.00	0.00	0.00	0.00	8.98E+09	0.00	2628.	0.00
4.8750	0.00	0.00	0.00	0.00	0.00	8.98E+09	0.00	2738.	0.00
5.0700	0.00	0.00	0.00	0.00	0.00	8.98E+09	0.00	2847.	0.00
5.2650	0.00	0.00	0.00	0.00	0.00	8.98E+09	0.00	2957.	0.00
5.4600	0.00	0.00	0.00	0.00	0.00	8.98E+09	0.00	3066.	0.00
5.6550	0.00	0.00	0.00	0.00	0.00	8.98E+09	0.00	3176.	0.00
5.8500	0.00	0.00	0.00	0.00	0.00	8.98E+09	0.00	3285.	0.00
6.0450	0.00	0.00	0.00	0.00	0.00	8.98E+09	0.00	3395.	0.00
6.2400	0.00	0.00	0.00	0.00	0.00	8.98E+09	0.00	3504.	0.00
6.4350	0.00	0.00	0.00	0.00	0.00	8.98E+09	0.00	3614.	0.00
6.6300	0.00	0.00	0.00	0.00	0.00	8.98E+09	0.00	3723.	0.00
6.8250	0.00	0.00	0.00	0.00	0.00	8.98E+09	0.00	3833.	0.00
7.0200	0.00	0.00	0.00	0.00	0.00	8.98E+09	0.00	3942.	0.00
7.2150	0.00	0.00	0.00	0.00	0.00	8.98E+09	0.00	4052.	0.00
7.4100	0.00	0.00	0.00	0.00	0.00	8.98E+09	0.00	4161.	0.00
7.6050	0.00	0.00	0.00	0.00	0.00	8.98E+09	0.00	4271.	0.00
7.8000	0.00	0.00	0.00	0.00	0.00	8.98E+09	0.00	4380.	0.00
7.9950	0.00	0.00	0.00	0.00	0.00	8.98E+09	0.00	4490.	0.00
8.1900	0.00	0.00	0.00	0.00	0.00	8.98E+09	0.00	4600.	0.00
8.3850	0.00	0.00	0.00	0.00	0.00	8.98E+09	0.00	4709.	0.00
8.5800	0.00	0.00	0.00	0.00	0.00	8.98E+09	0.00	4819.	0.00
8.7750	0.00	0.00	0.00	0.00	0.00	8.98E+09	0.00	4928.	0.00
8.9700	0.00	0.00	0.00	0.00	0.00	8.98E+09	0.00	5038.	0.00
9.1650	0.00	0.00	0.00	0.00	0.00	8.98E+09	0.00	5147.	0.00
9.3600	0.00	0.00	0.00	0.00	0.00	8.98E+09	0.00	5257.	0.00
9.5550	0.00	0.00	0.00	0.00	0.00	8.98E+09	0.00	5366.	0.00
9.7500	0.00	0.00	0.00	0.00	0.00	8.98E+09	0.00	5476.	0.00
9.9450	0.00	0.00	0.00	0.00	0.00	8.98E+09	0.00	5585.	0.00
10.1400	0.00	0.00	0.00	0.00	0.00	8.98E+09	0.00	5695.	0.00
10.3350	0.00	0.00	0.00	0.00	0.00	8.98E+09	0.00	5804.	0.00
10.5300	0.00	0.00	0.00	0.00	0.00	8.98E+09	0.00	5914.	0.00
10.7250	0.00	0.00	0.00	0.00	0.00	8.98E+09	0.00	6023.	0.00
10.9200	0.00	0.00	0.00	0.00	0.00	8.98E+09	0.00	6133.	0.00
11.1150	0.00	0.00	0.00	0.00	0.00	8.98E+09	0.00	6242.	0.00
11.3100	0.00	0.00	0.00	0.00	0.00	8.98E+09	0.00	6352.	0.00

11.5050	0.00	0.00	0.00	0.00	0.00	8.98E+09	0.00	6461.	0.00
11.7000	0.00	0.00	0.00	0.00	0.00	8.98E+09	0.00	6571.	0.00
11.8950	0.00	0.00	0.00	0.00	0.00	8.98E+09	0.00	6680.	0.00
12.0900	0.00	0.00	0.00	0.00	0.00	8.98E+09	0.00	6790.	0.00
12.2850	0.00	0.00	0.00	0.00	0.00	8.98E+09	0.00	6899.	0.00
12.4800	0.00	0.00	0.00	0.00	0.00	8.98E+09	0.00	7009.	0.00
12.6750	0.00	0.00	0.00	0.00	0.00	8.98E+09	0.00	7118.	0.00
12.8700	0.00	0.00	0.00	0.00	0.00	8.98E+09	0.00	7228.	0.00
13.0650	0.00	0.00	0.00	0.00	0.00	8.98E+09	0.00	351786.	0.00
13.2600	0.00	0.00	0.00	0.00	0.00	8.98E+09	0.00	351786.	0.00
13.4550	0.00	0.00	0.00	0.00	0.00	8.98E+09	0.00	351786.	0.00
13.6500	0.00	0.00	0.00	0.00	0.00	8.98E+09	0.00	351786.	0.00
13.8450	0.00	0.00	0.00	0.00	0.00	8.98E+09	0.00	351786.	0.00
14.0400	0.00	0.00	0.00	0.00	0.00	1.72E+09	0.00	223369.	0.00
14.2350	0.00	0.00	0.00	0.00	0.00	1.72E+09	0.00	223369.	0.00
14.4300	0.00	0.00	0.00	0.00	0.00	1.72E+09	0.00	223369.	0.00
14.6250	0.00	0.00	0.00	0.00	0.00	1.72E+09	0.00	223369.	0.00
14.8200	0.00	0.00	0.00	0.00	0.00	1.72E+09	0.00	223369.	0.00
15.0150	0.00	0.00	0.00	0.00	0.00	1.72E+09	0.00	223369.	0.00
15.2100	0.00	0.00	0.00	0.00	0.00	1.72E+09	0.00	223369.	0.00
15.4050	0.00	0.00	0.00	0.00	0.00	1.72E+09	0.00	223369.	0.00
15.6000	0.00	0.00	0.00	0.00	0.00	1.72E+09	0.00	223369.	0.00
15.7950	0.00	0.00	0.00	0.00	0.00	1.72E+09	0.00	223369.	0.00
15.9900	0.00	0.00	0.00	0.00	0.00	1.72E+09	0.00	223369.	0.00
16.1850	0.00	0.00	0.00	0.00	0.00	1.72E+09	0.00	223369.	0.00
16.3800	0.00	0.00	0.00	0.00	0.00	1.72E+09	0.00	223369.	0.00
16.5750	0.00	0.00	0.00	0.00	0.00	1.72E+09	0.00	223369.	0.00
16.7700	0.00	0.00	0.00	0.00	0.00	1.72E+09	0.00	223369.	0.00
16.9650	0.00	0.00	0.00	0.00	0.00	1.72E+09	0.00	223369.	0.00
17.1600	0.00	0.00	0.00	0.00	0.00	1.72E+09	0.00	223369.	0.00
17.3550	0.00	0.00	0.00	0.00	0.00	1.72E+09	0.00	223369.	0.00
17.5500	0.00	0.00	0.00	0.00	0.00	1.72E+09	0.00	223369.	0.00
17.7450	0.00	0.00	0.00	0.00	0.00	1.72E+09	0.00	223369.	0.00
17.9400	0.00	0.00	0.00	0.00	0.00	1.72E+09	0.00	223369.	0.00
18.1350	0.00	0.00	0.00	0.00	0.00	1.72E+09	0.00	223369.	0.00
18.3300	0.00	0.00	0.00	0.00	0.00	1.72E+09	0.00	223369.	0.00
18.5250	0.00	0.00	0.00	0.00	0.00	1.72E+09	0.00	223369.	0.00
18.7200	0.00	0.00	0.00	0.00	0.00	1.72E+09	0.00	223369.	0.00
18.9150	0.00	0.00	0.00	0.00	0.00	1.72E+09	0.00	223369.	0.00
19.1100	0.00	0.00	0.00	0.00	0.00	1.72E+09	0.00	223369.	0.00
19.3050	0.00	0.00	0.00	0.00	0.00	1.72E+09	0.00	223369.	0.00
19.5000	0.00	0.00	0.00	0.00	0.00	1.72E+09	0.00	111685.	0.00

* This analysis computed pile response using nonlinear moment-curvature relationships. Values of total stress due to combined axial and bending stresses are computed only for elastic sections only and do not equal the actual stresses in concrete and steel. Stresses in concrete and steel may be interpolated from the output for nonlinear bending properties relative to the magnitude of bending moment developed in the pile.

Output Summary for Load Case No. 2:

Pile-head deflection = 0.000000 inches
 Computed slope at pile head = 0.000000 radians
 Maximum bending moment = 0.000000 inch-lbs
 Maximum shear force = 0.000000 lbs
 Depth of maximum bending moment = 0.000000 feet below pile head
 Depth of maximum shear force = 0.000000 feet below pile head
 Number of iterations = 6
 Number of zero deflection points = 0

----- Pile-head Deflection vs. Pile Length for Load Case 2 -----

Boundary Condition Type 2, Shear and Slope

Shear = 0. lbs
 Slope = 0.00000
 Axial Load = 98240. lbs

Pile Length feet	Pile Head Deflection inches	Maximum Moment ln-lbs	Maximum Shear lbs
19.50000	0.000000	0.000000	0.000000
18.52500	0.000000	0.000000	0.000000
17.55000	0.000000	0.000000	0.000000
16.57500	0.000000	0.000000	0.000000
15.60000	0.000000	0.000000	0.000000
14.62500	0.000000	0.000000	0.000000
13.65000	0.000000	0.000000	0.000000
12.67500	0.000000	0.000000	0.000000
11.70000	0.000000	0.000000	0.000000
10.72500	0.000000	0.000000	0.000000
9.75000	0.000000	0.000000	0.000000
8.77500	0.000000	0.000000	0.000000
7.80000	0.000000	0.000000	0.000000
6.82500	0.000000	0.000000	0.000000
5.85000	0.000000	0.000000	0.000000
4.87500	0.000000	0.000000	0.000000
3.90000	0.000000	0.000000	0.000000
2.92500	0.000000	0.000000	0.000000
1.95000	0.000000	0.000000	0.000000

 Computed Values of Pile Loading and Deflection
 for Lateral Loading for Load Case Number 3

Pile-head conditions are Displacement and Pile-head Rotation (Loading Type 5)
 Displacement of pile head = 1.000000 inches
 Rotation of pile head = 0.000E+00 radians
 Axial load on pile head = 98240.0 lbs

Depth X feet	Deflect. y inches	Bending Moment in-lbs	Shear Force lbs	Slope S radians	Total Stress psi*	Bending Stiffness lb-in^2	Soil Res. p lb/inch	Soil Spr. Es*H lb/inch	Distrib. Lat. Load lb/inch
0.00	1.0000	-2065938.	31091.	0.00	0.00	7.94E+09	0.00	0.00	0.00
0.1950	0.9993	-1993134.	31076.	-5.98E-04	0.00	7.94E+09	-5.883	13.7766	0.00
0.3900	0.9972	-1920226.	31055.	-0.00117	0.00	7.96E+09	-12.595	29.5546	0.00
0.5850	0.9938	-1847258.	31017.	-0.00173	0.00	7.97E+09	-19.812	46.6505	0.00
0.7800	0.9891	-1774273.	30962.	-0.00226	0.00	7.98E+09	-27.235	64.4320	0.00
0.9750	0.9832	-1701318.	30889.	-0.00277	0.00	8.00E+09	-34.650	82.4641	0.00
1.1700	0.9762	-1628439.	30800.	-0.00325	0.00	8.01E+09	-41.860	100.3442	0.00
1.3650	0.9680	-1555679.	30694.	-0.00372	0.00	8.03E+09	-48.623	117.5409	0.00
1.5600	0.9588	-1483081.	30572.	-0.00416	0.00	8.04E+09	-55.547	135.5703	0.00
1.7550	0.9485	-1410688.	30435.	-0.00458	0.00	8.06E+09	-61.813	152.4948	0.00
1.9500	0.9373	-1338540.	30283.	-0.00498	0.00	8.08E+09	-67.723	169.0704	0.00
2.1450	0.9252	-1266673.	30119.	-0.00536	0.00	8.10E+09	-72.854	184.2606	0.00
2.3400	0.9122	-1195121.	29942.	-0.00571	0.00	8.12E+09	-78.087	200.3028	0.00
2.5350	0.8985	-1123917.	29753.	-0.00605	0.00	8.14E+09	-83.652	217.8652	0.00
2.7300	0.8839	-1053097.	29551.	-0.00636	0.00	8.17E+09	-89.181	236.0809	0.00
2.9250	0.8687	-982697.	29333.	-0.00665	0.00	8.20E+09	-96.915	261.0556	0.00
3.1200	0.8528	-912762.	29097.	-0.00692	0.00	8.23E+09	-104.502	286.7351	0.00
3.3150	0.8363	-843340.	28844.	-0.00717	0.00	8.26E+09	-111.878	313.0282	0.00
3.5100	0.8193	-774475.	28574.	-0.00740	0.00	8.30E+09	-118.981	339.8332	0.00
3.7050	0.8017	-706212.	28285.	-0.00761	0.00	8.35E+09	-128.473	374.9820	0.00
3.9000	0.7837	-638607.	27971.	-0.00779	0.00	8.40E+09	-139.875	417.6548	0.00
4.0950	0.7652	-571727.	27629.	-0.00796	0.00	8.47E+09	-151.687	463.8418	0.00
4.2900	0.7464	-505641.	27260.	-0.00811	0.00	8.54E+09	-163.901	513.8247	0.00
4.4850	0.7273	-440421.	26862.	-0.00824	0.00	8.63E+09	-176.536	567.9978	0.00

4.6800	0.7079	-376140.	26432.	-0.00835	0.00	8.73E+09	-190.475	629.6596	0.00
4.8750	0.6882	-312878.	25970.	-0.00844	0.00	8.98E+09	-204.937	696.8129	0.00
5.0700	0.6684	-250720.	25473.	-0.00851	0.00	8.98E+09	-219.920	769.9615	0.00
5.2650	0.6484	-189752.	24940.	-0.00857	0.00	8.98E+09	-235.426	849.6709	0.00
5.4600	0.6283	-130061.	24370.	-0.00861	0.00	8.98E+09	-251.453	936.5703	0.00
5.6550	0.6081	-71739.	23763.	-0.00864	0.00	8.98E+09	-268.003	1031.	0.00
5.8500	0.5878	-14880.	23115.	-0.00865	0.00	8.98E+09	-285.075	1135.	0.00
6.0450	0.5676	40419.	22428.	-0.00865	0.00	8.98E+09	-302.668	1248.	0.00
6.2400	0.5474	94058.	21698.	-0.00863	0.00	8.98E+09	-320.784	1371.	0.00
6.4350	0.5272	145935.	20926.	-0.00860	0.00	8.98E+09	-339.422	1507.	0.00
6.6300	0.5071	195944.	20109.	-0.00855	0.00	8.98E+09	-358.581	1655.	0.00
6.8250	0.4872	243979.	19247.	-0.00850	0.00	8.98E+09	-378.263	1817.	0.00
7.0200	0.4674	289927.	18338.	-0.00843	0.00	8.98E+09	-398.467	1995.	0.00
7.2150	0.4477	333677.	17382.	-0.00835	0.00	8.97E+09	-419.193	2191.	0.00
7.4100	0.4283	375111.	16376.	-0.00825	0.00	8.73E+09	-440.441	2406.	0.00
7.6050	0.4091	414110.	15320.	-0.00815	0.00	8.67E+09	-462.211	2644.	0.00
7.8000	0.3902	450553.	14226.	-0.00803	0.00	8.61E+09	-472.400	2833.	0.00
7.9950	0.3715	484380.	13116.	-0.00790	0.00	8.57E+09	-476.408	3001.	0.00
8.1900	0.3532	515569.	11998.	-0.00776	0.00	8.53E+09	-479.565	3177.	0.00
8.3850	0.3352	544100.	10873.	-0.00762	0.00	8.50E+09	-481.879	3364.	0.00
8.5800	0.3175	569957.	9744.	-0.00746	0.00	8.47E+09	-483.364	3562.	0.00
8.7750	0.3003	593131.	8612.	-0.00730	0.00	8.44E+09	-484.036	3772.	0.00
8.9700	0.2834	613618.	7479.	-0.00714	0.00	8.43E+09	-483.917	3996.	0.00
9.1650	0.2669	631415.	6348.	-0.00696	0.00	8.41E+09	-483.029	4235.	0.00
9.3600	0.2508	646527.	5222.	-0.00679	0.00	8.40E+09	-478.844	4468.	0.00
9.5550	0.2351	658976.	4126.	-0.00660	0.00	8.39E+09	-458.282	4561.	0.00
9.7500	0.2199	668873.	3078.	-0.00642	0.00	8.38E+09	-437.329	4654.	0.00
9.9450	0.2051	676332.	2080.	-0.00623	0.00	8.37E+09	-416.051	4747.	0.00
10.1400	0.1907	681470.	1131.	-0.00604	0.00	8.37E+09	-394.510	4840.	0.00
10.3350	0.1768	684404.	233.6388	-0.00585	0.00	8.37E+09	-372.767	4934.	0.00
10.5300	0.1633	685253.	-613.029	-0.00566	0.00	8.37E+09	-350.880	5027.	0.00
10.7250	0.1503	684136.	-1408.	-0.00547	0.00	8.37E+09	-328.903	5120.	0.00
10.9200	0.1378	681175.	-2152.	-0.00528	0.00	8.37E+09	-306.887	5213.	0.00
11.1150	0.1256	676489.	-2845.	-0.00509	0.00	8.37E+09	-284.883	5306.	0.00
11.3100	0.1140	670200.	-3486.	-0.00490	0.00	8.38E+09	-262.935	5399.	0.00
11.5050	0.1027	662428.	-4075.	-0.00471	0.00	8.38E+09	-241.086	5492.	0.00
11.7000	0.09191	653294.	-4614.	-0.00453	0.00	8.39E+09	-219.375	5585.	0.00
11.8950	0.08153	642916.	-5102.	-0.00435	0.00	8.40E+09	-197.839	5678.	0.00
12.0900	0.07157	631415.	-5540.	-0.00417	0.00	8.41E+09	-176.510	5771.	0.00
12.2850	0.06202	618906.	-5928.	-0.00400	0.00	8.42E+09	-155.420	5864.	0.00
12.4800	0.05287	605506.	-6268.	-0.00383	0.00	8.43E+09	-134.593	5957.	0.00
12.6750	0.04411	591331.	-6559.	-0.00366	0.00	8.45E+09	-114.056	6051.	0.00
12.8700	0.03574	576494.	-6802.	-0.00350	0.00	8.46E+09	-93.828	6144.	0.00
13.0650	0.02774	561107.	-10621.	-0.00334	0.00	8.48E+09	-3170.	267434.	0.00
13.2600	0.02010	528325.	-17210.	-0.00319	0.00	8.51E+09	-2462.	286602.	0.00
13.4550	0.01280	482030.	-22059.	-0.00305	0.00	8.57E+09	-1682.	307458.	0.00
13.6500	0.00581	426492.	-24987.	-0.00293	0.00	8.65E+09	-820.583	330259.	0.00
13.8450	-9.05E-04	366435.	-25790.	-0.00282	0.00	8.75E+09	134.7310	348292.	0.00
14.0400	-0.00740	307094.	-24852.	-0.00205	0.00	4.99E+08	666.8714	211016.	0.00
14.2350	-0.01052	251073.	-22987.	-9.57E-04	0.00	7.78E+08	927.1235	206263.	0.00
14.4300	-0.01187	199955.	-20689.	-3.71E-04	0.00	1.12E+09	1037.	204322.	0.00
14.6250	-0.01225	154418.	-18227.	-4.04E-05	0.00	1.48E+09	1068.	203847.	0.00
14.8200	-0.01206	114671.	-15746.	1.60E-04	0.00	1.71E+09	1053.	204204.	0.00
15.0150	-0.01151	80653.	-13335.	2.94E-04	0.00	1.71E+09	1008.	205093.	0.00
15.2100	-0.01069	52130.	-11052.	3.85E-04	0.00	1.71E+09	942.5776	206361.	0.00
15.4050	-0.00970	28753.	-8940.	4.40E-04	0.00	1.71E+09	862.1244	207881.	0.00
15.6000	-0.00863	10087.	-7028.	4.67E-04	0.00	1.71E+09	772.7077	209547.	0.00
15.7950	-0.00752	-4351.	-5329.	4.70E-04	0.00	1.71E+09	679.0454	211274.	0.00
15.9900	-0.00643	-15070.	-3850.	4.57E-04	0.00	1.71E+09	584.9912	212993.	0.00
16.1850	-0.00538	-22581.	-2588.	4.32E-04	0.00	1.71E+09	493.6080	214650.	0.00
16.3800	-0.00441	-27382.	-1534.	3.97E-04	0.00	1.71E+09	407.2252	216205.	0.00
16.5750	-0.00352	-29944.	-674.657	3.58E-04	0.00	1.71E+09	327.5007	217631.	0.00
16.7700	-0.00273	-30704.	7.4405	3.17E-04	0.00	1.71E+09	255.4891	218911.	0.00
16.9650	-0.00204	-30055.	530.6726	2.75E-04	0.00	1.71E+09	191.7179	220037.	0.00
17.1600	-0.00144	-28347.	914.4175	2.35E-04	0.00	1.71E+09	136.2692	221010.	0.00
17.3550	-9.37E-04	-25883.	1178.	1.98E-04	0.00	1.71E+09	88.8647	221836.	0.00
17.5500	-5.15E-04	-22926.	1339.	1.65E-04	0.00	1.71E+09	48.9484	222528.	0.00
17.7450	-1.65E-04	-19692.	1415.	1.36E-04	0.00	1.71E+09	15.7659	223099.	0.00
17.9400	1.21E-04	-16367.	1420.	1.11E-04	0.00	1.71E+09	-11.543	223172.	0.00

18.1350	3.55E-04	-13099.	1367.	9.11E-05	0.00	1.71E+09	-33.811	222795.	0.00
18.3300	5.47E-04	-10013.	1266.	7.53E-05	0.00	1.71E+09	-52.039	222489.	0.00
18.5250	7.08E-04	-7208.	1127.	6.35E-05	0.00	1.71E+09	-67.194	222236.	0.00
18.7200	8.45E-04	-4769.	954.3262	5.54E-05	0.00	1.71E+09	-80.144	222023.	0.00
18.9150	9.67E-04	-2767.	753.3457	5.02E-05	0.00	1.71E+09	-91.634	221836.	0.00
19.1100	0.00108	-1266.	526.4707	4.75E-05	0.00	1.72E+09	-102.276	221664.	0.00
19.3050	0.00119	-325.197	275.1576	4.64E-05	0.00	1.72E+09	-112.522	221499.	0.00
19.5000	0.00130	0.00	0.00	4.62E-05	0.00	1.72E+09	-122.656	110669.	0.00

* This analysis computed pile response using nonlinear moment-curvature relationships. Values of total stress due to combined axial and bending stresses are computed only for elastic sections only and do not equal the actual stresses in concrete and steel. Stresses in concrete and steel may be interpolated from the output for nonlinear bending properties relative to the magnitude of bending moment developed in the pile.

Output Summary for Load Case No. 3:

Pile-head deflection = 1.00000000 inches
 Computed slope at pile head = 0.000000 radians
 Maximum bending moment = -2065938. inch-lbs
 Maximum shear force = 31091. lbs
 Depth of maximum bending moment = 0.000000 feet below pile head
 Depth of maximum shear force = 0.000000 feet below pile head
 Number of iterations = 14
 Number of zero deflection points = 2

Summary of Pile-head Responses for Conventional Analyses

Definitions of Pile-head Loading Conditions:

Load Type 1: Load 1 = Shear, V, lbs, and Load 2 = Moment, M, in-lbs
 Load Type 2: Load 1 = Shear, V, lbs, and Load 2 = Slope, S, radians
 Load Type 3: Load 1 = Shear, V, lbs, and Load 2 = Rot. Stiffness, R, in-lbs/rad.
 Load Type 4: Load 1 = Top Deflection, y, inches, and Load 2 = Moment, M, in-lbs
 Load Type 5: Load 1 = Top Deflection, y, inches, and Load 2 = Slope, S, radians

Load Case No.	Load Type 1	Pile-head Load 1	Load Type 2	Pile-head Load 2	Axial Loading lbs	Pile-head Deflection inches	Pile-head Rotation radians	Max Shear in Pile lbs	Max Moment in Pile in-lbs
1	V, lb	5180.	S, rad	0.00	137250.	0.09593	0.00	5180.	-274164.
2	V, lb	0.00	S, rad	0.00	98240.	0.00	0.00	0.00	0.00
3	y, in	1.0000	S, rad	0.00	98240.	1.0000	0.00	31091.	-2065938.

Maximum pile-head deflection = 1.000000000 inches
 Maximum pile-head rotation = -0.000000000 radians = -0.000000 deg.

The analysis ended normally.

LAMSON ENGINEERING CORPORATION		Final Page No:	
Project:	Bridge No. W-38-003, Wilmington	Job No:	Preliminary Sheet No:
Subject:	Wingwall Type 3 - 10.75 Dia. Micropile	Prepared by: SL	Date: 5/2023
Detail:	Summary of Micropile Resistance	Checked by: JG	Date: 5/2023

Summary of Micropile Resistance - Retaining Wall Type 3

Steel Casing: 10.75 in. O.D. x 0.595 in., $F_y = 52$ ksi, Wall Thickness = 0.595 in.

Steel Reinforcing Bar: #14, Threaded, Grade 60

Compressive strength of micropile grout at 28 days: $f'_c = 5$ ksi

Rock Socket Diameter = 9.56 in.

Estimated Bonded Length into Rock (Grout into intact bedrock) = 5.5 ft.

Plunge Length (Casing into Intact Bedrock) = 1 ft

Nominal Geotechnical Pile Resistance per Pile = 297.3 kips

Side Resistance Factor, ϕ_{stat} = 0.55

Factored Geotechnical Pile Resistance per Pile = 163.5 kips > 118.7 k OK

Nominal Uplift Resistance per Pile = 148.7 kips

Resistance Factor, ϕ_{up} = 0.55

Factored Uplift Resistance per Pile = 81.8 kips > 72 k OK

Nominal Structural Pile Resistance per Pile = 1096.9 k (Portion of Cased Length)

Nominal Structural Pile Resistance per Pile = 366.0 k (Portion of Uncased Length)

Compression Resistance Factor, ϕ_C = 0.75

Factored Structural Pile Resistance per Pile = 822.7 k (Portion of Cased Length)

Factored Structural Pile Resistance per Pile = 274.5 k (Portion of Uncased Length)

LAMSON ENGINEERING CORPORATION		Final Page No:	
Project:	Bridge No. W-38-003, Wilmington	Job No:	Preliminary Sheet No:
Subject:	Wingwall Type 3 - 10.75 Dia. Micropile	Prepared by: SL	Date: 5/2023
Detail:	Summary of Micropile Resistance	Checked by: JG	Date: 5/2023

Nominal Tension Resistance = 995.0 k (Portion of Cased Length)

Nominal Tension Resistance = 135.1 k (Portion of Uncased Length)

Tension Resistance Factor, ϕ_T = 0.8





Factored Tension Resistance = 796.0 k (Portion of Cased Length)

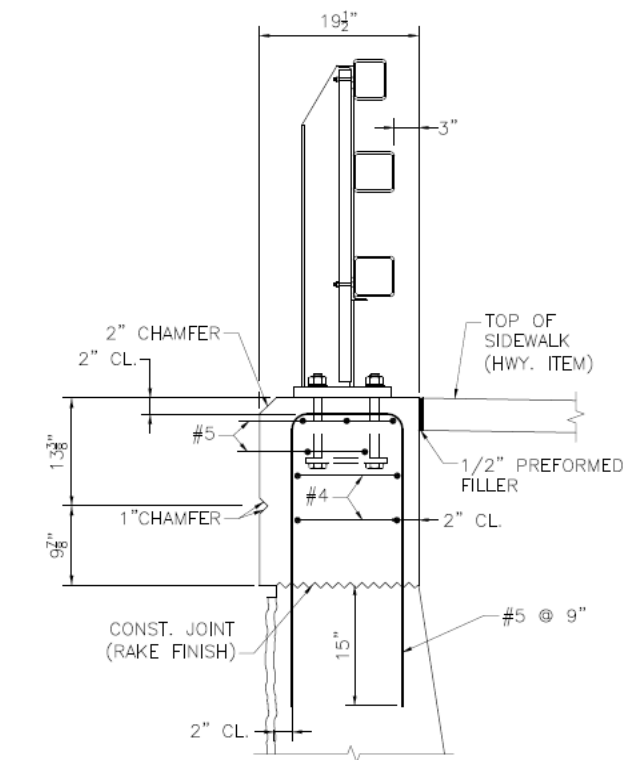
Factored Tension Resistance = 108.1 k (Portion of Uncased Length)

LAMSON ENGINEERING CORPORATION		Final Page No.:	
Project: Bridge No. W-38-003	Job No.:	Preliminary Sheet No.:	
Subject: Retaining Wall Type 3	Prepared by: SL	Date: 5/2023	
Detail: Unfactored Vertical Load	Checked by: JG	Date: 5/2023	

Retaining Wall Type 3

Unfactored Vertical Load

	W (ft)	H (ft)	unit weight		
Coping	(1.63)	(1.94)	(0.15 kcf)	=	0.47 k/ft
Stem 	(1.54)	(12.95)	(0.15 kcf)	=	2.99 k/ft
Stem 	0.5 (1.08)	(12.95)	(0.15 kcf)	=	1.05 k/ft
Concrete Footing	(8.00)	(2.50)	(0.15 kcf)	=	3.00 k/ft
Vertical Soil 1 	0.5 (1.08)	(14.89)	(0.12 kcf)	=	0.96 k/ft
Vertical Soil 2 	(3.42)	(14.89)	(0.12 kcf)	=	6.11 k/ft
Bridge Railing S3-TL4 at Sidewalk				=	0.090 k/ft



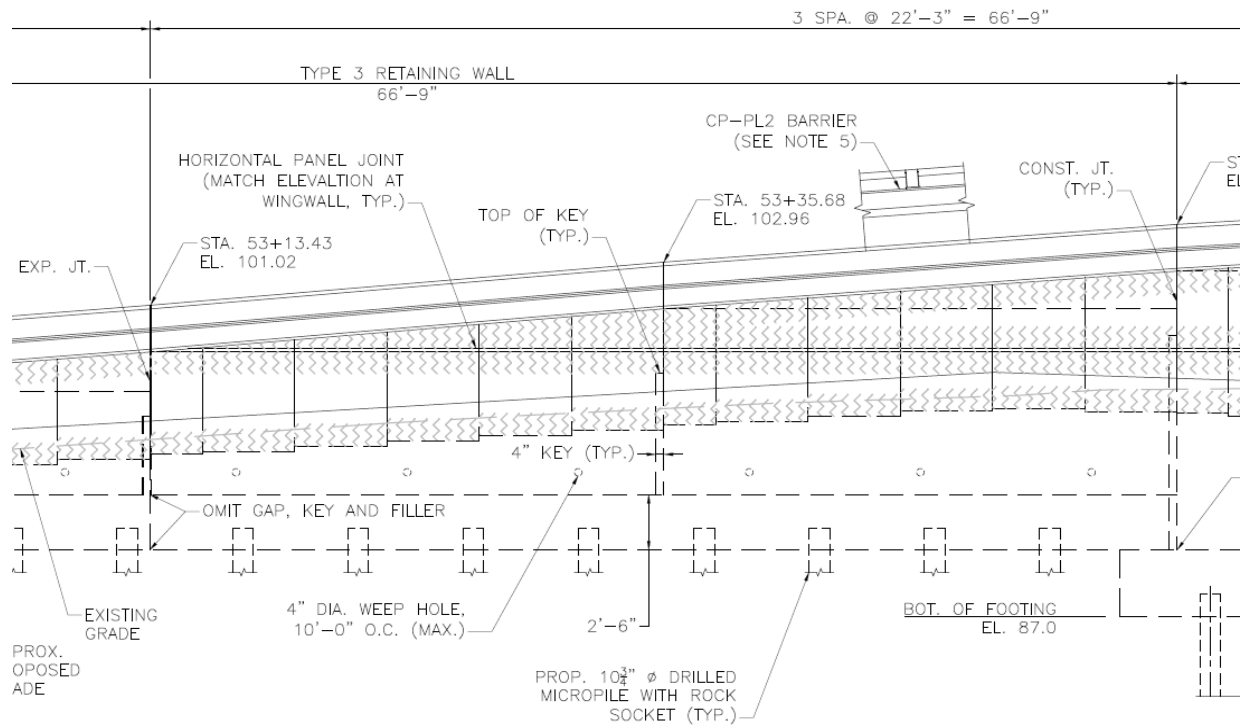
TOP OF U-WINGWALL/RETAINING WALL
DETAILS AT SIDEWALK

LAMSON ENGINEERING CORPORATION				Final Page No.:	
Project: Bridge No. W-38-003		Job No.:		Preliminary Sheet No.:	
Subject: Retaining Wall Type 3		Prepared by: SL		Date: 5/2023	
Detail: Unfactored Vertical Load		Checked by: JG		Date: 5/2023	

Retaining Wall Type 3

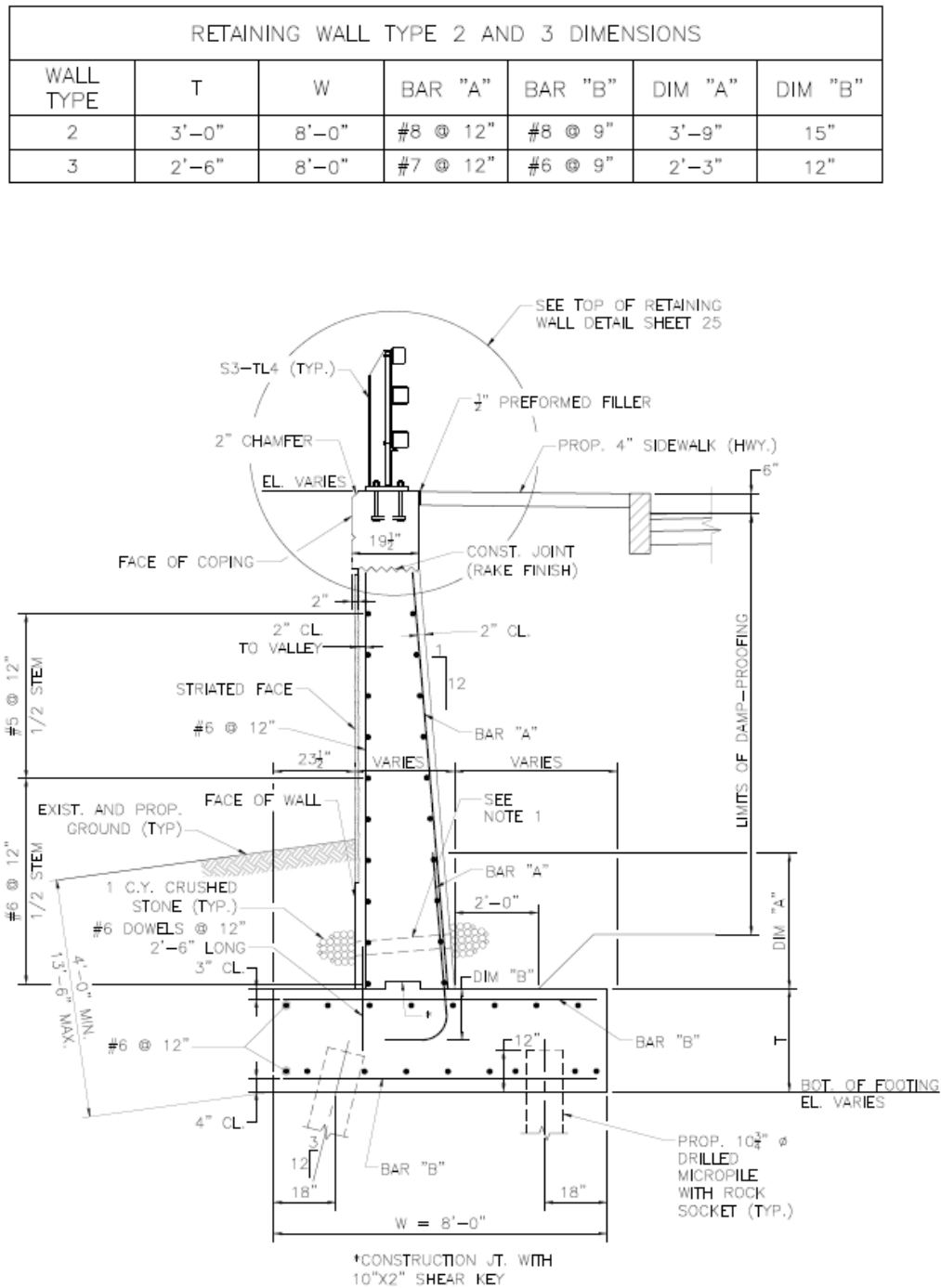
STA.	Elevation	STA.	Elevation	Length (ft.)	Bottom of Footing Elevation	Design H at highest 1/4 point (ft)	
53+13.43	101.02	53+57.93	104.66	44.5	90	17.39	SW Retaining Wall
55+31.50	105.81	55+52.16	104.52	20.7	90.5	14.99	SE Retaining Wall
52+66.45	97.45	52+42.35	95.94	24.1	82	15.07	NW Retaining Wall

By Investigations above, Southwest Retaining Wall could provide the control values for Micropile Design.



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Project: Bridge No. W-38-003	Job No.:	Preliminary Sheet No.:	
Subject: Retaining Wall Type 3	Prepared by: SL	Date: 5/2023	
Detail: Unfactored Vertical Load	Checked by: JG	Date: 5/2023	

Retaining Wall Type 3



RETAINING WALL TYPE 2 AND 3 TYPICAL SECTION

LAMSON ENGINEERING CORPORATION		Final Page No.:
Project: Bridge No. W-38-003	Job No.:	Preliminary Sheet No.:
Subject: Retaining Wall Type 3	Prepared by: SL	Date: 5/2023
Detail: Lateral earth pressure	Checked by: JG	Date: 5/2023

Determine Unfactored Horizontal Load

Effective angle of internal friction ϕ'_f	=	37	degree
Friction angle between fill and wall, δ	=	0	degree
Angle of fill to the horizontal, β	=	0.00	degree
Angle of back of wall to the horizontal, θ	=	90	degree
Unit weight of soil, γ_{soil}	=	0.125	kcf
Total unit weight of water, γ_w	=	0.0624	kcf
Height of Soil	=	17.39	ft ±
Distance from back of wall to footing heel, B_{heel}	=	4.50	ft
Height of fill behind footing at heel, $h = H + B_{heel} \tan \beta$	=	17.39	ft ±
Height of water from bottom of footing, H_w	=	0	ft

Lateral Earth Pressure (EH)

$$K_a = \frac{\sin^2(\theta + \phi'_f)}{\sin^2\theta \sin(\theta - \delta) \left[1 + \sqrt{\frac{\sin(\phi'_f + \delta) \sin(\phi'_f - \beta)}{\sin(\theta - \delta) \sin(\theta + \beta)}} \right]^2}$$

$$= 0.249$$

$$K_o = 1 - \sin \phi'_f = 1 - \sin(37)$$

$$= 0.398$$

Per *massDOT* LRFD BM 3.1.5

Founded on Pile = Y (Input Y if yes)

$$K_e = K_o = 0.398$$

$$= 0.398$$

$$P_{e1} = 0.5 K_e \gamma_{soil} (h - H_w)^2$$

$$= 0.5 \times 0.398 \times 0.125 \text{ kcf} \times (17.39 \text{ ft} - 0 \text{ ft})^2$$

$$= 7.53 \text{ k/ft length of wall}$$

$$P_{ev1} = P_{e1} \sin(90 - \theta + \delta)$$

$$= 7.53 \text{ k/ft} \times \sin(90 - 90 + 0)$$

$$= 0.00 \text{ k/ft}$$

LAMSON ENGINEERING CORPORATION		Final Page No.:
Project: Bridge No. W-38-003	Job No.:	Preliminary Sheet No.:
Subject: Retaining Wall Type 3	Prepared by: SL	Date: 5/2023
Detail: Lateral earth pressure	Checked by: JG	Date: 5/2023

$$\begin{aligned}
 \text{Horizontal component of } P_{e1}, P_{eh1} &= P_{e1} \cos (90 - \theta + \delta) \\
 &= 7.53 \text{ k/ft} \times \cos (90 - 90 + 0) \\
 &= 7.53 \text{ k/ft}
 \end{aligned}$$

$$\begin{aligned}
 \text{Lateral earth pressure, } P_{e2} &= K_e \gamma_{\text{soil}} (h - H_w) H_w \\
 &= 0.398 \times 0.125 \text{ kcf} \times (17.39 \text{ ft} - 0 \text{ ft}) \times 0 \text{ ft} \\
 &= 0.00 \text{ k/ft length of wall}
 \end{aligned}$$

$$\begin{aligned}
 \text{Vertical component of } P_{e2}, P_{ev2} &= P_{e2} \sin (90 - \theta + \delta) \\
 &= 0 \text{ k/ft} \times \sin (90 - 90 + 0) \\
 &= 0.00 \text{ k/ft}
 \end{aligned}$$

$$\begin{aligned}
 \text{Horizontal component of } P_{e2}, P_{eh2} &= P_{e2} \cos (90 - \theta + \delta) \\
 &= 0 \text{ k/ft} \times \cos (90 - 90 + 0) \\
 &= 0.00 \text{ k/ft}
 \end{aligned}$$

$$\begin{aligned}
 \text{Lateral earth pressure, } P_{e3} &= 0.5 K_e \gamma' (H_w)^2 \\
 &= 0.5 \times 0.398 \times (0.125 \text{ kcf} - 0.0624 \text{ kcf}) \times 0 \text{ ft}^2 \\
 &= 0.00 \text{ k/ft length of wall}
 \end{aligned}$$

$$\begin{aligned}
 \text{Vertical component of } P_{e3}, P_{ev3} &= P_{e3} \sin (90 - \theta + \delta) \\
 &= 0 \text{ k/ft} \times \sin (90 - 90 + 0) \\
 &= 0.00 \text{ k/ft}
 \end{aligned}$$

$$\begin{aligned}
 \text{Horizontal component of } P_{e3}, P_{eh3} &= P_{e3} \cos (90 - \theta + \delta) \\
 &= 0 \text{ k/ft} \times \cos (90 - 90 + 0) \\
 &= 0.00 \text{ k/ft}
 \end{aligned}$$

LAMSON ENGINEERING CORPORATION		Final Page No.:
Project: Bridge No. W-38-003	Job No.:	Preliminary Sheet No.:
Subject: Retaining Wall Type 3	Prepared by: SL	Date: 5/2023
Detail: Lateral earth pressure	Checked by: JG	Date: 5/2023

Live Load Surcharge (LS) (AASHTO LRFD 3.11.6.4)

$$\text{Equivalent height of soil for, } h_{eq} = 2.000 \text{ ft}$$

$$\begin{aligned} \text{Vertical live load Surcharge on heel, LS} &= 0.125 \text{ kcf} \times 2 \text{ ft} \times 4.5 \text{ ft} \\ &= 1.125 \text{ k / ft} \end{aligned}$$

$$\begin{aligned} \text{Horizontal earth pressure due to live load surcharge } \Delta_p &= K_e \gamma_{\text{soil}} h_{eq} \\ &= 0.398 \times 0.125 \text{ kcf} \times 2 \text{ ft} \\ &= 0.10 \text{ ksf} \end{aligned}$$

$$\begin{aligned} \text{Live load lateral earth pressure, } P_{LS} &= \Delta_p h \\ &= 0.1 \text{ ksf} \times 17.39 \text{ ft} \\ &= 1.73 \text{ k/ft length of wall} \end{aligned}$$

$$\begin{aligned} \text{Vertical component of } P_{LS}, P_{LSV} &= P_{LS} \sin (90 - \alpha + \delta) \\ &= 1.73 \text{ k/ft} \times \sin (90 - 90 + 0) \\ &= 0.00 \text{ k/ft length of wall} \end{aligned}$$

$$\begin{aligned} \text{Horizontal component of } P_{LS}, P_{LSH} &= P_{LS} \cos (90 - \alpha + \delta) \\ &= 1.73 \text{ k/ft} \times \cos (90 - 90 + 0) \\ &= 1.73 \text{ k/ft length of wall} \end{aligned}$$

$$\begin{aligned} \text{Unfactored horizontal load, EH + LSH} &= P_{eh1} + P_{eh2} + P_{eh3} + P_{LSH} \\ &= 7.53 + 0 + 0 + 1.73 \\ &= \underline{9.26 \text{ k/ft length of wall}} \end{aligned}$$

LAMSON ENGINEERING CORPORATION				Final Page No.:	
Project: Bridge No. W-38-003, Wilmington		Job No.:		Preliminary Sheet No.:	
Subject: Retaining Wall Type 3		Prepared by: SL		Date: 5/2023	
Detail: Pile_STR I_VMAX		Checked by: JG		Date: 5/2023	

Pile STR I VMAX

Cross Section = 0.63 ft.²

Number of Pile, n = 14

Length to Wall 44.50 ft

Factored Load at Bottom of Pile Cap Through Centroid of the Pile Group:

No. of Battered Piles = 9

Factored Horizontal Resistance (Front Piles battered 1:4) = $163.53 \times 9 \text{ ea} / 4 = 817.7$ kips

Vertical, $F_z = 935.76$ kips

$F_y = 586.93 - 817.67 = 0.00$ kips

$F_x = 0.00$ kips

$M_x = (-17.82 + 85.24) \text{ k-ft/ft} \times 44.5 \text{ ft} + 935.76 \text{ k} \times -0.71 \text{ ft}$
= 2331.48 k-ft

$M_y = 0.00$ kips-ft

Pile #	A_p (sf)	X_i (ft.)	Y_i (ft.)	$A_p X_i$ (ft. ³)	$A_p Y_i$ (ft. ³)	dx^2 $(X_i - X_{C.G.})^2$	dy^2 $(Y_i - Y_{C.G.})^2$	$\frac{M_x(Y_{C.G.} - Y_i)}{\sum (Y_i - Y_{C.G.})^2}$	$\frac{M_y(X_{C.G.} - X_i)}{\sum (X_i - X_{C.G.})^2}$	F_z / n	$\sum F_z$ (kips)	Shear F_y / n	Shear F_x / n
1	0.63	0.00	-2.50	0.000	-1.576	411.752	3.189	51.81	0.00	66.840	118.65	0.00	0.00
2	0.63	5.00	-2.50	3.151	-1.576	233.835	3.189	51.81	0.00	66.840	118.65	0.00	0.00
3	0.63	10.00	-2.50	6.303	-1.576	105.918	3.189	51.81	0.00	66.840	118.65	0.00	0.00
4	0.63	15.00	-2.50	9.454	-1.576	28.002	3.189	51.81	0.00	66.840	118.65	0.00	0.00
5	0.63	20.00	-2.50	12.606	-1.576	0.085	3.189	51.81	0.00	66.840	118.65	0.00	0.00
6	0.63	25.00	-2.50	15.757	-1.576	22.168	3.189	51.81	0.00	66.840	118.65	0.00	0.00
7	0.63	30.00	-2.50	18.909	-1.576	94.252	3.189	51.81	0.00	66.840	118.65	0.00	0.00
8	0.63	35.00	-2.50	22.060	-1.576	216.335	3.189	51.81	0.00	66.840	118.65	0.00	0.00
9	0.63	42.04	-2.50	26.499	-1.576	473.063	3.189	51.81	0.00	66.840	118.65	0.00	0.00
1	0.63	0.00	2.50	0.000	1.576	411.752	10.332	-93.26	0.00	66.840	-26.42	0.00	0.00
2	0.63	10.00	2.50	6.30	1.576	105.92	10.33	-93.26	0.00	66.84	-26.42	0.00	0.00
3	0.63	20.00	2.50	12.606	1.576	0.085	10.332	-93.26	0.00	66.840	-26.42	0.00	0.00
4	0.63	30.00	2.50	18.909	1.576	94.252	10.332	-93.26	0.00	66.840	-26.42	0.00	0.00
5	0.63	42.04	2.50	26.499	1.576	473.063	10.332	-93.26	0.00	66.840	-26.42	0.00	0.00
14	8.82			179.06	-6.30						118.65	0.00	
											-26.42	0.00	

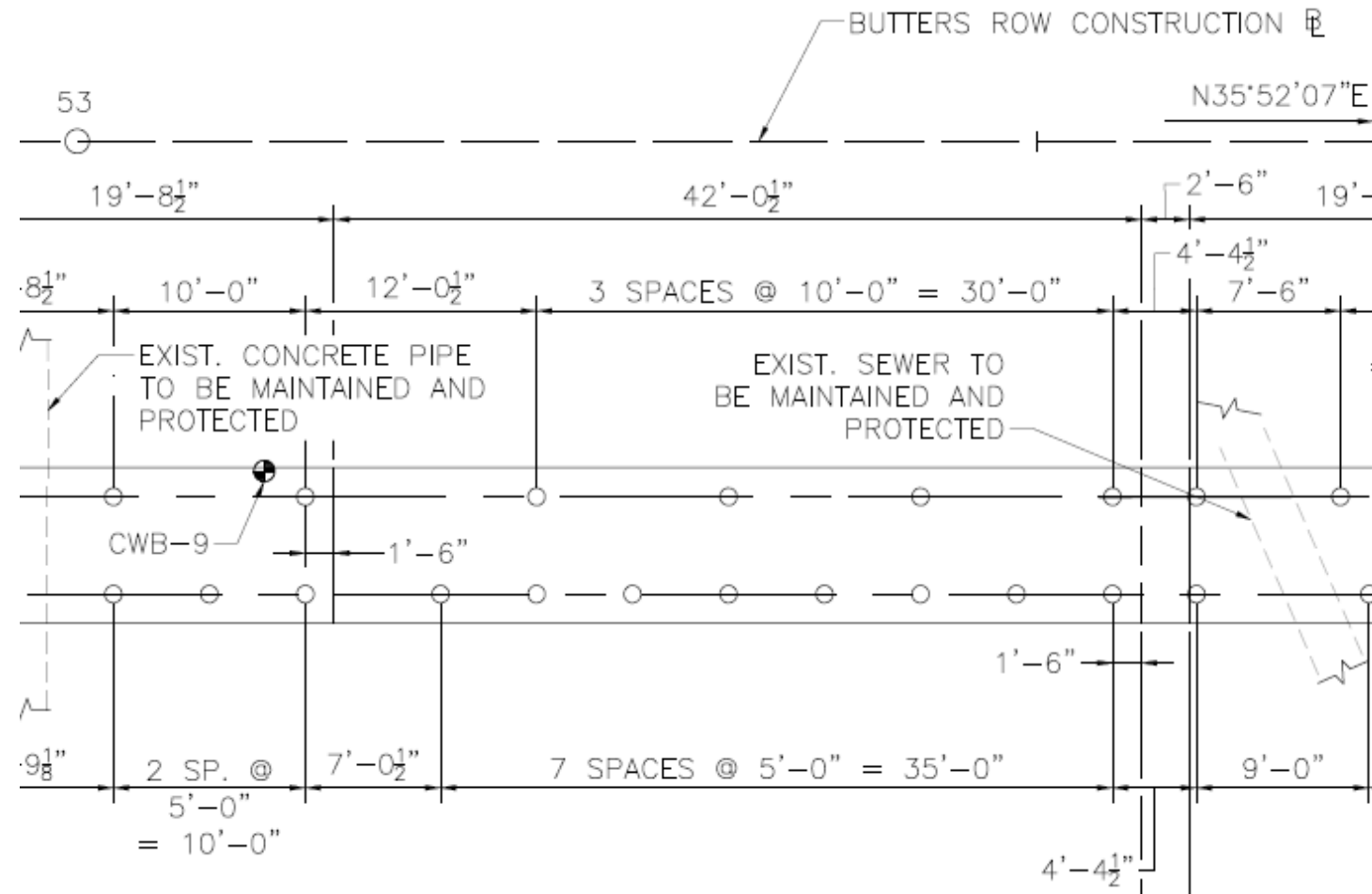
$X_{C.G.} = \sum A_p X_i / \sum A_p = 179.06 / 8.82 = 20.292 \text{ ft.}$ $Y_{C.G.} = \sum A_p Y_i / \sum A_p = -6.30 / 8.82 = -0.714 \text{ ft.}$ from Pile Cap Center

$\sum (X_i - X_{C.G.})^2 = 2670 \text{ ft.}^2$ $\sum (Y_i - Y_{C.G.})^2 = 80.36 \text{ ft.}^2$

Resultant Shear on Single Pile = $(0.00^2 + 0.00^2)^{0.5} = 0.00$ kips

LAMSON ENGINEERING CORPORATION		Final Page No.:	
Project: Bridge No. W-38-003, Wilmington	Job No.:	Preliminary Sheet No.:	
Subject: Retaining Wall Type 3	Prepared by: SL	Date:	5/2023
Detail: Pile_STR I_VMAX	Checked by: JG	Date:	5/2023

Pile STR I_VMAX







Pile Layout

LAMSON ENGINEERING CORPORATION			Final Page No.:	
Project:	Bridge No. W-38-003	Job No.:	Preliminary Sheet No.:	
Subject:	Retaining Wall Type 3	Prepared by: SL		Date: 5/2023
Detail:	Strength I for Overturning	Checked by: JG		Date: 5/2023

Summary of Factored Loads - Strength IA: 1.25DC + 1.35EH + 1.35EV + 1.75 LS

Vertical Loads and Vertical Moments

Item	Load Factor γ	Vertical load, V (k/ft)	Factored vertical load, V_u (k/ft)	Arm about ⌒ Footing	Factored Moment	
Coping	1.25	0.47	0.59	1.31	0.77	
Stem 	1.25	2.99	3.74	1.27	4.76	
Stem 	1.25	1.05	1.31	0.14	0.18	
Concrete Footing	1.25	3.00	3.75	0.00	0.00	
Vertical Soil 1 	1.35	0.96	1.30	-0.22	-0.29	
Vertical Soil 2 	1.35	6.11	8.25	-2.29	-18.89	
Bridge Railing	1.25	0.09	0.11	1.31	0.15	
P_{v1}	1.35	0.00	0.00	-4.00	0.00	
P_{v2}	1.35	0.00	0.00	-4.00	0.00	
P_{v3}	1.35	0.00	0.00	-4.00	0.00	
P_{LSV}	1.75	0.00	0.00	-4.00	0.00	
LS	1.75	1.13	1.97	-2.29	-4.51	
TOTAL		15.81	21.03		-17.82	ΣM_v

Horizontal Loads and Horizontal Moments

Item	Load Factor γ	Horizontal load H (k/ft)	Factored horizontal load, H_u (k/ft)	Arm about ⌒ Footing	Factored Moment	
P_{h1}	1.35	7.53	10.16	5.80	58.89	
P_{h2}	1.35	0.00	0.00	0.00	0.00	
P_{h3}	1.35	0.00	0.00	0.00	0.00	
P_{LSH}	1.75	1.73	3.03	8.70	26.34	
TOTAL		9.26	13.19		85.24	ΣM_H

LAMSON ENGINEERING CORPORATION			Final Page No.:	
Project:	Bridge No. W-38-003	Job No.:	Preliminary Sheet No.:	
Subject:	Retaining Wall Type 3	Prepared by: SL	Date: 5/2023	
Detail:	Strength I for Sliding and Eccentricity	Checked by: JG	Date: 5/2023	

Summary of Factored Loads - Strength IB: 0.90DC + 1.35EH + 1.0EV + 1.75 LS

Vertical Loads and Vertical Moments

Item	Load Factor γ	Vertical load, V (k/ft)	Factored vertical load, V_u (k/ft)	Arm about CL Footing	Factored Moment	
Coping	0.90	0.47	0.43	1.31	0.56	
Stem	0.90	2.99	2.70	1.27	3.43	
Stem	0.90	1.05	0.94	0.14	0.13	
Concrete Footing	0.90	3.00	2.70	0.00	0.00	
Vertical Soil 1	1.00	0.96	0.96	-0.22	-0.21	
Vertical Soil 2	1.00	6.11	6.11	-2.29	-13.99	
Bridge Railing	0.90	0.09	0.08	1.31	0.11	
P_{v1}	1.35	0.00	0.00	-4.00	0.00	
P_{v2}	1.35	0.00	0.00	-4.00	0.00	
P_{v3}	1.35	0.00	0.00	-4.00	0.00	
P_{LSV}	1.75	0.00	0.00	-4.00	0.00	
LS	1.75	0.00	0.00	-2.29	0.00	
TOTAL		14.68	13.92		-9.98	ΣM_v

Horizontal Loads and Horizontal Moments

Item	Load Factor γ	Horizontal load H (k/ft)	Factored horizontal load, H_u (k/ft)	Arm about CL Footing	Factored Moment	
P_{h1}	1.35	7.53	10.16	5.80	58.89	
P_{h2}	1.35	0.00	0.00	0.00	0.00	
P_{h3}	1.35	0.00	0.00	0.00	0.00	
P_{LSH}	1.75	1.73	3.03	8.70	26.34	
TOTAL		9.26	13.19		85.24	ΣM_H

LAMSON ENGINEERING CORPORATION		Final Page No.:	
Project: Bridge No. W-38-003, Wilmington	Job No.:	Preliminary Sheet No.:	
Subject: Retaining Wall Type 3	Prepared by: SL	Date:	5/2023
Detail: Pile_STR I_VMIN	Checked by: JG	Date:	5/2023

Pile STR I VMIN

Cross Section = 0.63 ft.²

Number of Pile, n = 14

Length between Expansion Joints = 44.50 ft

Factored Load at Bottom of Pile Cap Through Centroid of the Pile Group:

No. of Battered Piles = 9

Factored Horizontal Resistance (Front Piles battered 1:4) = 163.53 x 9 ea / 4 = 817.7 kips

Vertical, F_z = 619.49 kips

F_y = 586.93 - 817.67 = 0.00 kips

F_x = 0.00 kips

M_x = (-9.98+85.24) k-ft/ft x 44.5 ft + 619.49 k x -0.71 ft
= 2906.18 k-ft

M_y = 0.00 kips-ft

Pile #	A _p (sf)	X _i (ft.)	Y _i (ft.)	A _p X _i (ft. ³)	A _p Y _i (ft. ³)	dx ² (X _i - X _{C.G.}) ²	dy ² (Y _i - Y _{C.G.}) ²	$\frac{M_x(Y_{C.G.} - Y_i)}{\sum (Y_i - Y_{C.G.})^2}$	$\frac{M_y(X_{C.G.} - X_i)}{\sum (X_i - X_{C.G.})^2}$	F _z / n	Σ F _z (kips)	Shear F _y / n	Shear F _x / n
1	0.63	0.00	-2.50	0.000	-1.576	411.752	3.189	64.58	0.00	44.249	108.83	0.00	0.00
2	0.63	5.00	-2.50	3.151	-1.576	233.835	3.189	64.58	0.00	44.249	108.83	0.00	0.00
3	0.63	10.00	-2.50	6.303	-1.576	105.918	3.189	64.58	0.00	44.249	108.83	0.00	0.00
4	0.63	15.00	-2.50	9.454	-1.576	28.002	3.189	64.58	0.00	44.249	108.83	0.00	0.00
5	0.63	20.00	-2.50	12.606	-1.576	0.085	3.189	64.58	0.00	44.249	108.83	0.00	0.00
6	0.63	25.00	-2.50	15.757	-1.576	22.168	3.189	64.58	0.00	44.249	108.83	0.00	0.00
7	0.63	30.00	-2.50	18.909	-1.576	94.252	3.189	64.58	0.00	44.249	108.83	0.00	0.00
8	0.63	35.00	-2.50	22.060	-1.576	216.335	3.189	64.58	0.00	44.249	108.83	0.00	0.00
9	0.63	42.04	-2.50	26.499	-1.576	473.063	3.189	64.58	0.00	44.249	108.83	0.00	0.00
1	0.63	0.00	2.50	0.000	1.576	411.752	10.332	-116.25	0.00	44.249	-72.00	0.00	0.00
2	0.63	10.00	2.50	6.303	1.576	105.918	10.332	-116.25	0.00	44.249	-72.00	0.00	0.00
3	0.63	20.00	2.50	12.61	1.58	0.09	10.33	-116.25	0.00	44.25	-72.00	0.00	0.00
4	0.63	30.00	2.50	18.91	1.58	94.25	10.33	-116.25	0.00	44.25	-72.00	0.00	0.00
5	0.63	42.04	2.50	26.50	1.58	473.06	10.33	-116.25	0.00	44.25	-72.00	0.00	0.00
14	8.82			179.06	-6.30						108.83	0.00	
											-72.00	0.00	

X_{C.G.} = ΣA_p X_i / ΣA_p = 179.06 / 8.82 = 20.292 ft. Y_{C.G.} = ΣA_p Y_i / ΣA_p = -6.30 / 8.82 = -0.714 ft.

Σ(X_i-X_{C.G.})² = 2670 ft.² Σ(Y_i-Y_{C.G.})² = 80.36 ft.²

Resultant Shear on Single Pile = (0.00² + 0.00²)^{0.5} = 0.00 kips

LAMSON ENGINEERING CORPORATION		Final Page No.:
Project: Bridge No. W-38-003	Job No.:	Preliminary Sheet No.:
Subject: Retaining Wall Type 3	Prepared by: SL	Date: 5/2023
Detail: Service I for Settlement	Checked by: JG	Date: 5/2023

Summary of Factored Loads - Service I: 1.0DC + 1.0EH + 1.0EV

Vertical Loads and Vertical Moments

Item	Load Factor γ	Vertical load, V (k/ft)	Factored vertical load, V_u (k/ft)	Arm about CL Footing	Factored Moment
Coping	1.00	0.47	0.47	1.31	0.62
Stem	1.00	2.99	2.99	1.27	3.81
Stem	1.00	1.05	1.05	0.14	0.15
Concrete Footing	1.00	3.00	3.00	0.00	0.00
Vertical Soil 1	1.00	0.96	0.96	-0.22	-0.21
Vertical Soil 2	1.00	6.11	6.11	-2.29	-13.99
Bridge Railing	1.00	0.09	0.09	1.31	0.12
P_{v1}	1.00	0.00	0.00	-4.00	0.00
P_{v2}	1.00	0.00	0.00	-4.00	0.00
P_{v3}	1.00	0.00	0.00	-4.00	0.00
P_{LSV}	1.00	0.00	0.00	-4.00	0.00
LS	1.00	1.13	1.13	-2.29	-2.58
TOTAL		15.81	15.81		-12.09

ΣM_v

Horizontal Loads and Horizontal Moments

Item	Load Factor γ	Horizontal load H (k/ft)	Factored horizontal load, H_u (k/ft)	Arm about CL Footing	Factored Moment
P_{h1}	1.00	7.53	7.53	5.80	43.63
P_{h2}	1.00	0.00	0.00	0.00	0.00
P_{h3}	1.00	0.00	0.00	0.00	0.00
P_{LSH}	1.00	1.73	1.73	8.70	15.05
TOTAL		9.26	9.26		58.68

ΣM_H

LAMSON ENGINEERING CORPORATION		Final Page No.:	
Project: Bridge No. W-38-003, Wilmington	Job No.:	Preliminary Sheet No.:	
Subject: Retaining Wall Type 3	Prepared by: SL	Date:	5/2023
Detail: Pile_SERVICE I	Checked by: JG	Date:	5/2023

Pile_SERVICE I

Cross Section = 0.63 ft.²

Number of Pile, n = 14

Length to Expansion Joint = 44.50 ft

Factored Load at Bottom of Pile Cap Through Centroid of the Pile Group:

No. of Battered Piles = 9

Factored Horizontal Resistance (Front Piles battered 1:4) = 163.53 x 9 ea / 4 = 817.7 kips

Vertical, F_z = 703.39 kips

F_y = 411.94 - 817.67 = 0.00 kips

F_x = 0.00 kips

M_x = (-12.09+58.68) k-ft/ft x 44.5 ft + 703.39 k x -0.71 ft
= 1570.67 k-ft

M_y = 0.00 kips-ft

Pile #	A _p (sf)	X _i (ft.)	Y _i (ft.)	A _p X _i (ft. ³)	A _p Y _i (ft. ³)	dx ² (X _i - X _{C.G.}) ²	dy ² (Y _i - Y _{C.G.}) ²	$\frac{M_x(Y_{C.G.} - Y_i)}{\sum (Y_i - Y_{C.G.})^2}$	$\frac{M_y(X_{C.G.} - X_i)}{\sum (X_i - X_{C.G.})^2}$	F _z / n	Σ F _z (kips)	Shear F _y / n	Shear F _x / n
1	0.63	0.00	-2.50	0.000	-1.576	411.752	3.189	34.90	0.00	50.242	85.15	0.00	0.00
2	0.63	5.00	-2.50	3.151	-1.576	233.835	3.189	34.90	0.00	50.242	85.15	0.00	0.00
3	0.63	10.00	-2.50	6.303	-1.576	105.918	3.189	34.90	0.00	50.242	85.15	0.00	0.00
4	0.63	15.00	-2.50	9.454	-1.576	28.002	3.189	34.90	0.00	50.242	85.15	0.00	0.00
5	0.63	20.00	-2.50	12.606	-1.576	0.085	3.189	34.90	0.00	50.242	85.15	0.00	0.00
6	0.63	25.00	-2.50	15.757	-1.576	22.168	3.189	34.90	0.00	50.242	85.15	0.00	0.00
7	0.63	30.00	-2.50	18.909	-1.576	94.252	3.189	34.90	0.00	50.242	85.15	0.00	0.00
8	0.63	35.00	-2.50	22.060	-1.576	216.335	3.189	34.90	0.00	50.242	85.15	0.00	0.00
9	0.63	42.04	-2.50	26.499	-1.576	473.063	3.189	34.90	0.00	50.242	85.15	0.00	0.00
1	0.63	0.00	2.50	0.000	1.576	411.752	10.332	-62.83	0.00	50.242	-12.58	0.00	0.00
2	0.63	10.00	2.50	6.303	1.576	105.918	10.332	-62.83	0.00	50.242	-12.58	0.00	0.00
3	0.63	20.00	2.50	12.606	1.576	0.085	10.332	-62.83	0.00	50.242	-12.58	0.00	0.00
4	0.63	30.00	2.50	18.909	1.576	94.252	10.332	-62.83	0.00	50.242	-12.58	0.00	0.00
5	0.63	42.04	2.50	26.499	1.576	473.063	10.332	-62.83	0.00	50.242	-12.58	0.00	0.00
14	8.82			179.06	-6.30						85.15	0.00	
											-12.58	0.00	

X_{C.G.} = ΣA_p X_i / ΣA_p = 179.06 / 8.82 = 20.292 ft.

Y_{C.G.} = ΣA_p Y_i / ΣA_p = -6.30 / 8.82 = -0.714 ft.

Σ(X_i-X_{C.G.})² = 2670 ft.² Σ(Y_i-Y_{C.G.})² = 80.36 ft.²

Resultant Shear on Single Pile = (0.00² + 0.00²)^{0.5} = 0.00 kips

LAMSON ENGINEERING CORPORATION		Final Page No:	
Project:	Bridge No. W-38-003, Wilmington	Job No:	Preliminary Sheet No:
Subject:	Wingwall Type 3 - 10.75 Dia. Micropile	Prepared by: SL	Date: 12/2022
Detail:	Micropile Vertical Resistance	Checked by: JG	Date: 12/2022

Axial Compression Resistance

Based on Boring BB-1 $O.D.$ = 10.75 in. t_{wall} = 0.595 in.

$$R_R = \text{Factored Resistance of a micropile}$$

$$= \phi R_n = \phi_{qp} R_p + \phi_{qs} R_s$$

in which:

$$R_p = q_p A_p$$

$$R_s = q_s A_s$$

where:

$$R_p = \text{nominal tip resistance}$$

(Per AASHTO C10.9.3.5.1, tip resistance is neglected for conservative)

$$R_s = \text{nominal grout to ground bond resistance}$$

$$\phi_{qp} = \text{resistance factor for tip resistance}$$

$$= 0.50 \quad (\text{AASHTO 10.5.5.2.5-1})$$

(Note: No tip resistance considered in this calculation.)

$$\phi_{qs} = \text{resistance factor for grout-to-ground resistance}$$

$$= 0.55 \quad (\text{AASHTO 10.5.5.2.5-1})$$

$$d_p = \text{diameter of micropile tip}$$

$$= 9.56 \text{ in.}$$

$$A_p = \text{area of micropile tip} = \pi D^2/4$$

$$= 71.78 \text{ in.}^2 = 0.50 \text{ ft}^2$$

$$R_s = \pi d_b \alpha_b L_b$$

in which:

$$d_b = \text{diameter of micropile drill hole through bonded length}$$

$$= 9.56 \text{ in.} = 0.80 \text{ ft}$$

$$\alpha_b = \text{nominal micropile grout-to-ground bond strength}$$

$$= 21.6 \text{ ksf for Type A Diorite}$$

(AASHTO Table C10.9.3.5.2 - 1)

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Detail:	Micropile Vertical Resistance	Checked by: JG	Date: 12/2022

$$L_b = \text{micropile bonded length}$$

$$= 5.5 \text{ ft into Intact Bedrock}$$

$$\phi_{qs} R_s = 0.55 \times 3.141 \times 0.8 \times [21.6 \times 5.5]$$

$$= 163.5 \text{ kips}$$

$$R_n = 163.53 / 0.55 = \underline{297 \text{ kips}}$$

$$R_R = \underline{164 \text{ kips}}$$

Uplift Resistance

$$\text{Uplift Resistance} = 50 \% \text{ of the compression resistance}$$

$$= 0.5 \times 163.5 = \underline{82 \text{ kips}}$$

$$\phi_{up} = \text{resistance factor}$$

$$= 0.55$$

$$\text{Nominal Resistance} = 81.8 / 0.55 = \underline{149 \text{ kips}}$$

Structural Resistance

Axial Compression Resistance

$$R_C = \text{Factored Structural Resistance of a micropile}$$

$$= \phi_c R_n$$

in which:

$$\phi_c = \text{resistance factor for tip resistance}$$

$$= 0.75 \quad (\text{AASHTO 10.5.5.2.5-2})$$

$$R_n = \text{Nominal axial compression resistance}$$

• For the cased length

$$F_y = 52 \text{ ksi}$$

$$f_y = 60 \text{ ksi} \quad (\text{Reinforcing Bar Grade 60})$$

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Detail:	Micropile Vertical Resistance	Checked by:	JG	Date: 12/2022

$$R_n = 0.85 [0.85 f'_c A_g + f_y (A_b + A'_c)]$$

where:

$$f'_c = \text{specified compressive strength of micropile grout at 28 days}$$

$$= 5.0 \text{ ksi}$$

$$f_y = \text{specified minimum yield strength of reinforcement bar or steel casing, or stress in steel reinforcement bar or casing at a strain of 0.003, whichever is less}$$

$$\text{Min. } (F_y, f_y) = 52.0 \text{ ksi}$$

$$d_b = 1.69 \text{ in. } \#14 \text{ threaded bar}$$

$$A_b = \text{cross-section area of steel reinforcing bar}$$

$$= 2.25 \text{ in.}^2$$

$$A_c = \text{cross-section area of steel casing}$$

$$= 18.98 \text{ in.}^2$$

$$A'_c = \text{cross-section area of steel casing with 1/16" section loss on outside of the casing}$$

$$= 16.9 \text{ in.}^2 \quad \text{Section loss} = 0.063 \text{ in.}$$

$$A_g = \text{cross-section area of grout within micropile}$$

$$= A_{ID} - A_b = 71.78 - 2.25$$

$$= 69.53 \text{ in.}^2$$

$$R_n = 0.85 \times [0.85 \times 5 \times 69.53 + 52 \times (2.25 + 16.88)]$$

$$= 1096.9 \text{ kips}$$

$$R_{CC} = 0.75 \times 1096.9 = \underline{823 \text{ kips}}$$

• For the uncased length

$$R_n = 0.85 [0.85 f'_c A_g + f_y A_b]$$

$$f_y = \text{specified minimum yield strength of reinforcement bar or stress in steel reinforcement bar at a strain of 0.003, whichever is less}$$

$$= 60.0 \text{ ksi}$$

$$= 60 \text{ ksi}$$

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$$R_n = 0.85 \times [0.85 \times 5 \times 69.53 + 60 \times 2.25]$$

$$= 366.0 \quad \text{kips}$$

$$R_{CU} = 0.75 \times 366 = \underline{274 \quad \text{kips}}$$

Axial Tension Resistance

$$R_T = \text{factored Structural Resistance of a micropile}$$

$$= \phi_T R_n$$

in which:

$$\phi_T = \text{resistance factor for tip resistance}$$

$$= 0.80 \quad (\text{AASHTO 10.5.5.2.5-2})$$

$$R_n = \text{nominal axial tension resistance}$$

• For the cased length

$$R_n = f_y (A_b + A'_c)$$

$$= 52 \times (2.25 + 16.88) = 995.0 \quad \text{kips}$$

$$R_{TC} = 0.8 \times 995 = \underline{796 \quad \text{kips}}$$

• For the uncased length

$$R_n = f_y A_b$$

$$= 60 \times 2.25 = 135.1 \quad \text{kips}$$

$$R_{TU} = 0.8 \times 135.1 = \underline{108 \quad \text{kips}}$$

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Project:	Bridge No. W-38-003, Wilmington	Job No:	Preliminary Sheet No:
Subject:	Wingwall Micropile Foundation	Prepared by: SL	Date: 12/2022
Detail:	Lpile Analysis	Checked by: JG	Date: 12/2022

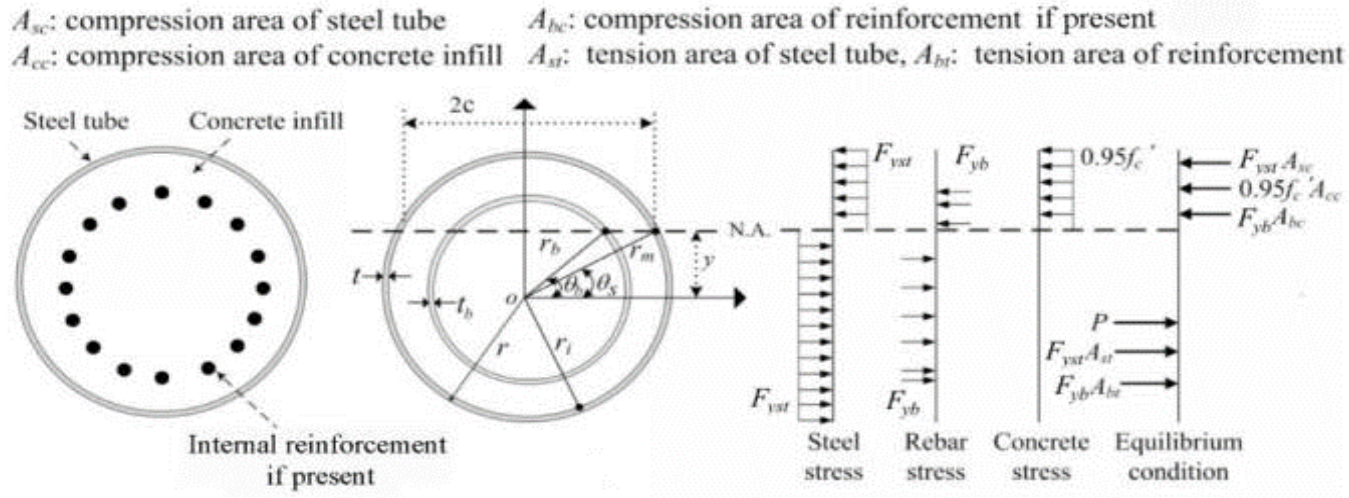


Figure C6.12.2.3.3-1—PSDM Model

$$\begin{aligned}
 P_n = & F_{yst} t r_m \left[(\pi - 2\theta_s) - (\pi + 2\theta_s) \right] \\
 & + t_b r_b \left[F_{yb} (\pi - 2\theta_b) - (F_{yb} - 0.95f'_c) (\pi + 2\theta_b) \right] \\
 & + \frac{0.95f'_c}{2} \left[(\pi - 2\theta_s) r_i^2 - 2yc \right]
 \end{aligned}
 \tag{C6.12.2.3.3-1}$$

$$\begin{aligned}
 M_n = & 0.95f'_c c \left[(r_i^2 - y^2) - \frac{c^2}{3} \right] + 4F_{yst} t c \frac{r_m^2}{r_i} + 4F_{yb} t_b c_b r_b
 \end{aligned}
 \tag{C6.12.2.3.3-2}$$

in which:

$$r_m = r - \frac{t}{2}
 \tag{C6.12.2.3.3-3}$$

$$\theta_s = \sin^{-1} \left(\frac{y}{r_m} \right)
 \tag{C6.12.2.3.3-4}$$

$$\theta_b = \sin^{-1} \left(\frac{y}{r_b} \right)
 \tag{C6.12.2.3.3-5}$$

$$c = r_i \cos \theta_s
 \tag{C6.12.2.3.3-6}$$

$$c_b = r_b \cos \theta_b
 \tag{C6.12.2.3.3-7}$$

$$t_b = \frac{nA_b}{2\pi r_b}
 \tag{C6.12.2.3.3-8}$$

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Yield Strength, $F_{yst} = 52.00$ ksi
 Strength of Concrete, $f'_c = 5.00$ ksi
 Resistance factor for CFST in compression, $\phi_c = 0.90$ (AASHTO 6.5.4.2)
 Yield Strength, $F_{yb} = 60.00$ ksi
 (AASHTO 6.9.6.2 Limitations) $D/t = 20.0 < 0.15 E / F_{yst} = 83.7$ **OK**
 Concrete shall be greater than 3 ksi or $0.075 F_{yst} = 3.9$ ksi < 5.00 ksi **OK**

$A_s = 2.25$ in² Cover = 3.934 in.
 $r = 5.313$ in. $t = 0.5325$ in.
 $r_m = 5.046$ in.
 $r_i = 4.780$ in.
 $r_b = 0.000$ in. Internal reinforcement is not considered.
 Number of reinforcing bars, $n = 1.0$
 $t_b = n A_s / (2 \pi r_b) = 0$ in.

Strength I

Factored Moment = 0.0 k-ft from Lpile
 Factored Axial Load = 118.7 k from Lpile

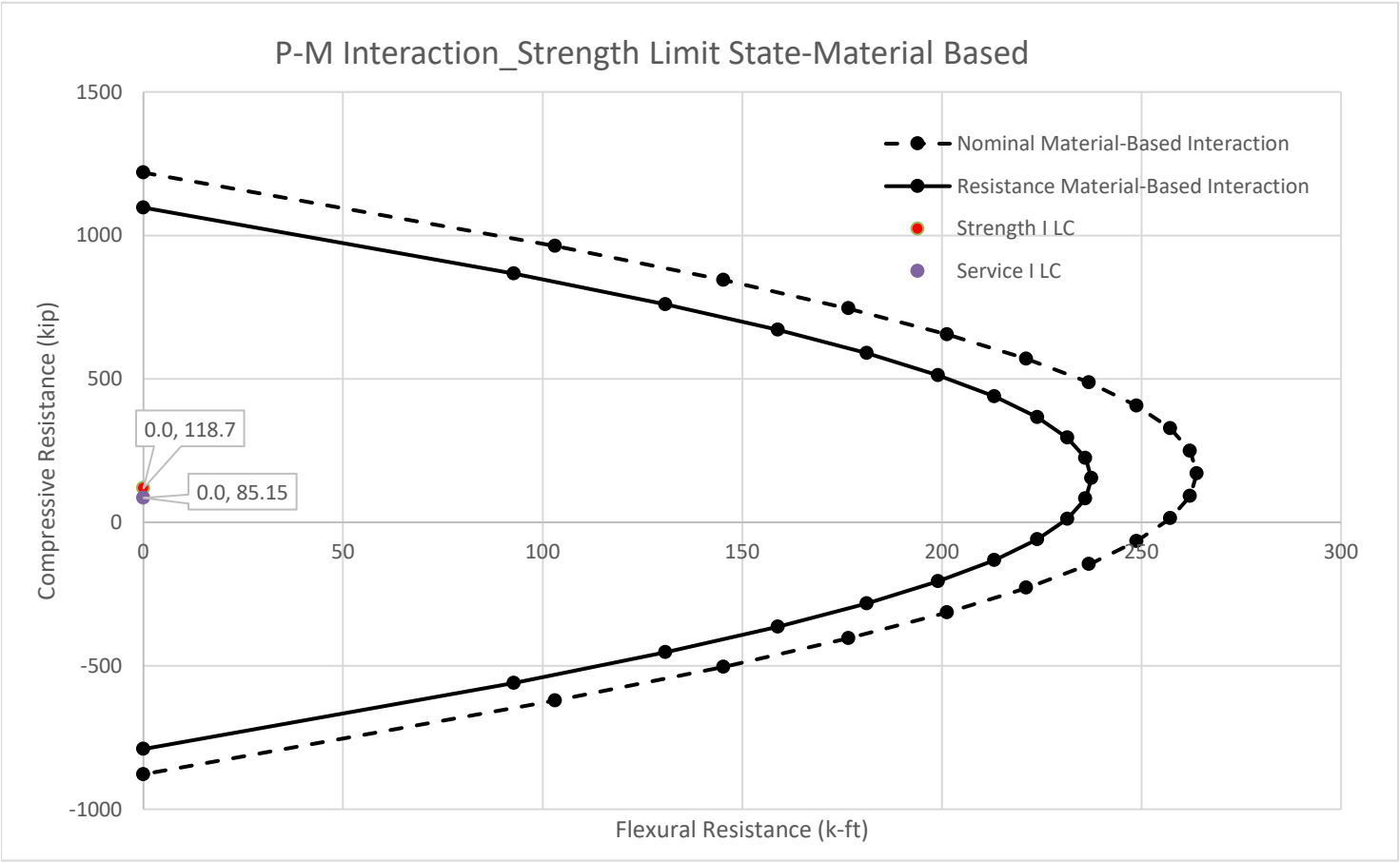
Service I

Factored Moment = 0.0 k-ft from Lpile
 Factored Axial Load = 85.15 k from Lpile

Composite Concrete-Filled Steel Tubes (CFSTs) (AASHTO LRFD 6.12.2.3.3)

y (in.)	θ_s (rad)	θ_b (rad)	$c = r_i \cos \theta_b$	$c_b = r_b \cos \theta_b$	$\pi - 2 \theta_s$	$\pi + 2 \theta_s$	M_n (kips-ft)	P_n (kips)	$\phi_c M_n$ (kips-ft)	$\phi_c P_n$ (kips)
-5.05	-1.57	-1.57	0.00	0.00	6.28	0.00	0.00	1218.91	0.00	1097.02
-4.54	-1.12	-1.57	2.08	0.00	5.38	0.90	103.09	962.82	92.78	866.54
-4.04	-0.93	-1.57	2.87	0.00	5.00	1.29	145.35	844.40	130.81	759.96
-3.53	-0.78	-1.57	3.41	0.00	4.69	1.59	176.62	745.30	158.95	670.77
-3.03	-0.64	-1.57	3.82	0.00	4.43	1.85	201.36	654.98	181.23	589.48
-2.52	-0.52	-1.57	4.14	0.00	4.19	2.09	221.20	569.57	199.08	512.61
-2.02	-0.41	-1.57	4.38	0.00	3.96	2.32	236.88	487.15	213.19	438.44
-1.51	-0.30	-1.57	4.56	0.00	3.75	2.53	248.81	406.64	223.93	365.97
-1.01	-0.20	-1.57	4.68	0.00	3.54	2.74	257.20	327.33	231.48	294.59
-0.50	-0.10	-1.57	4.76	0.00	3.34	2.94	262.20	248.74	235.98	223.86
0.00	0.00	1.57	4.78	0.00	3.14	3.14	263.86	170.48	237.47	153.43
0.50	0.10	1.57	4.76	0.00	2.94	3.34	262.20	92.22	235.98	83.00
1.01	0.20	1.57	4.68	0.00	2.74	3.54	257.20	13.63	231.48	12.27
1.51	0.30	1.57	4.56	0.00	2.53	3.75	248.81	-65.68	223.93	-59.11
2.02	0.41	1.57	4.38	0.00	2.32	3.96	236.88	-146.19	213.19	-131.57
2.52	0.52	1.57	4.14	0.00	2.09	4.19	221.20	-228.61	199.08	-205.75
3.03	0.64	1.57	3.82	0.00	1.85	4.43	201.36	-314.02	181.23	-282.62
3.53	0.78	1.57	3.41	0.00	1.59	4.69	176.62	-404.34	158.95	-363.90
4.04	0.93	1.57	2.87	0.00	1.29	5.00	145.35	-503.44	130.81	-453.10
4.54	1.12	1.57	2.08	0.00	0.90	5.38	103.09	-621.86	92.78	-559.68
5.05	1.57	1.57	0.00	0.00	0.00	6.28	0.00	-877.95	0.00	-790.16

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Detail:	Lpile Analysis	Checked by:	JG	Date: 12/2022



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Detail:	Lpile Analysis	Checked by: JG	Date: 12/2022

Notes

Based on the design loads for Strength and Service Load Combinations, the horizontal resistance due to the front row of battered piles is greater than the factored earth pressure load.

The micropiles at Retaining Wall Type 1 or Type 2 will control for the pile design.

The micropile at Retaining Wall Type 3 does not control for the pile design.

No Lpile Analysis is needed for Retaining Wall Type 3 Micropile.